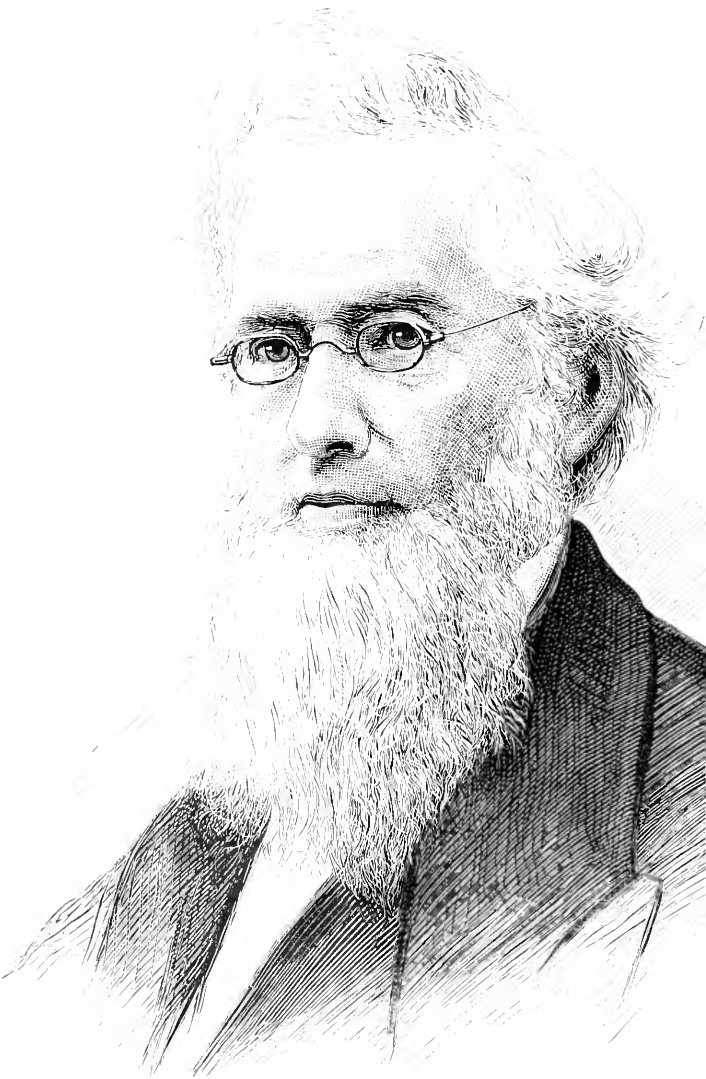

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THE

POPULAR SCIENCE MONTHLY.

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GAR-PIKES, OLD AND YOUNG.

By Professor BURT G. WILDER,
OF CORNELL UNIVERSITY.

I.

SOME readers of The Popular Science Monthly may never have seen gar-pikes, or even heard of them. The word does not occur in some of the dictionaries, and the animals themselves are found alive only in certain parts of the world. So, before telling what gar-pikes do, it is necessary to explain what they are.

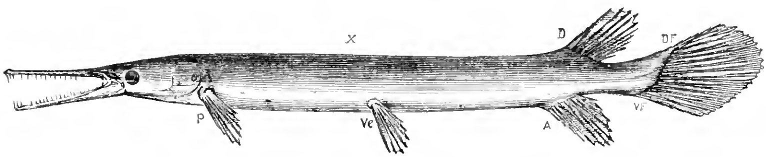


Fig. 1.—The Short-nosed Gar-Pike (*Lepidosteus platystomus*), Nearly adult, one-fourth natural length. *O*, the gill cover, or operculum. *P*, the pectoral, and *Ve*, the ventral, fin of the left side. *D* and *A*, the dorsal and anal fins. *DF* and *VF*, the "fulcra" which cover the dorsal and ventral borders of the root of the tail. *X* indicates the point where the section shown in Fig. 3 was made. The scales are shown in the next figure.

In the first place, the gar-pike is not a weapon, but a *vertebrated animal*. The vertebrates include all animals having a spine or backbone made up of a series of segments or *vertebræ*. But this common definition is not wholly accurate. For the very young of man and monkeys, quadrupeds and birds, reptiles and fishes, have no skeleton at all; and some of the lowest fishes, the *Amphioxus* and the lamprey-eels, have no bones. So the vertebrates are now said to include all animals having a longitudinal axis or spine (whether membrane, cartilage, or bone) separating an upper or dorsal cavity, containing the spinal cord and brain, from a lower or ventral cavity, containing

the stomach, intestine, heart, and other organs of vegetative life. This is shown in Fig. 3.

Let us now go one step further and learn what kind of a vertebrate is the gar-pike. At present the most natural primary subdivision of the branch seems to be into three great groups. The highest

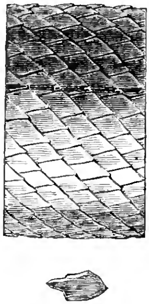


Fig. 2.—Part of the Side of the Body of *Lepidosteus platystomus*, Natural size, showing the arrangement of the enameled scales. Below is an outline of a single scale; the point is covered by the scale in front.

is the Mammalia, comprising our common quadrupeds, also bats, monkeys and men, seals and whales. The females of all these bring forth their young alive, and nourish them with milk.

Next come the Sauropsida, including birds, turtles, crocodiles, lizards, and snakes. Lastly, the Ichthyopsida, embracing the Batrachians (frogs, toads, and salamanders), and all other vertebrates.

Evidently, our gar-pike is neither a mammal nor a bird, a turtle, a snake, nor a lizard. It does look a little like an alligator, but it has not only fins and scales, but also *gills*, which are not known to exist in any reptile; while all the Ichthyopsida have gills during at least a part of their lives. The gar-pike is neither a frog nor a toad; it has scales and fin-rays unlike salamanders. Why, then, not call it a *fish?*

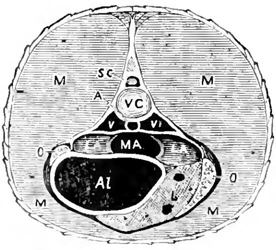


Fig. 3.—Cross-Section (Natural Size) of the Short-nosed Gar-Pike (*Lepidosteus platystomus*),

Showing the general arrangement of the organs which is characteristic of vertebrates. The section is made in front of the ventral fins at the point indicated by *X* on Fig. 1. The cut surface is looked at from behind. Near the middle is the vertebral column or backbone (*VC*). Above it is the spinal cord (*SC*), surrounded by bony walls. Below are the abdominal viscera. *A* is the median aorta, *V V* the lateral veins. *MA* is the median channel of the air-bladder, and *LA*, *LA*, are its lateral chambers. The cavity of the stomach (*Al*) is on the left, and the liver (*L*), with two veins, on the right. *O*, *O* are the two ovaries, of which the left lies farther forward so that its section is smaller. The whole is surrounded by the muscular walls of the body (*M*, *M*, *M*, *M*), and this again is covered by the plates of the skin.

Because, unfortunately, we are not sure that there are any "fishes." The terms "beast, bird, and fish," notwithstanding common usage and the sanction of Scripture, are devoid of scientific accuracy. For "beast" includes turtles and alligators, and excludes the aquatic mammals, whales, porpoises, manatee, and dugong. "Bird" includes bats and pterodactyls, and excludes the ostriches and penguins, which cannot fly. So "fish" is not only held by some persons to embrace the aquatic mammals, but also, when employed in a stricter sense, it includes forms differing among themselves in many important points.

At any rate, the "fish-like vertebrates" present the following well-marked groups:

1. *Amphioxus lanceolatus;* the lancelet. A single genus with perhaps a single species, but so peculiar as to have received the following appellations: Branchiostoma, Cirrostomi, Pharyngobranchii, Leptocardia, Acrania, Entomocrania, Dermopteri.
2. Myzonts, or Marsipobranchii; the hag-fishes and lamprey-eels.
3. Plagiostomes, or Elasmobranchii; sharks and skates.
4. Holocephala; the *Chimæra* and *Callorhynchus.*
5. Ganoids; the sturgeons (*Acipenser* and *Scaphyrhynchus*); the spoonbill (*Polyodon*); the mud-fish (*Amia*); the gar-pike (*Lepidosteus*); and the *Polypterus* and *Calamoichthys* of Africa, with many fossil forms.
6. Dipnoans; the mud-fishes of Africa, South America, and Australia (*Protopterus*, *Lepidosiren*, and *Ceratodus*).

All of the above were formerly, and are now popularly, regarded as *fishes.*

But the fishes proper, or ordinary fishes, are now called:

7. Teleosts; the perch, salmon, cod, mackerel, and all others not included within the other six groups.

Some have included *Amphioxus* with the Myzonts; others the Plagiostomes with the Ganoids. The most natural combination seems to be that of the Ganoids with the Teleosts; and to this larger group the term Pisces has been applied. But for the present it is safer to recognize the distinctions, and to make our generalizations more exact.

What, then, is a gar-pike? Is it a Ganoid or a Teleost? Curiously enough, the prefix "gar" (signifying a dart or pointed weapon) is employed to designate two fishes, of which one (*Belone*) is a marine Teleost, and the other (*Lepidosteus*) is a fluviatile Ganoid. Both have long jaws with sharp teeth, but in other respects they are very unlike. It will be better to call *Belone* the "gar-*fish*" and *Lepidosteus* the gar-*pike.*[1]

The general appearance of the gar-pike is sufficiently indicated by

[1] These common names are very perplexing. Thus the true pike is *Esox.* The name dog-fish is popularly applied to *Menobranchus*, a batrachian; to *Amia*, a ganoid; and to *Acanthias*, a shark.

the figure. The body is an elongated cylinder covered with hard and shining scales closely joined, and leaving as vulnerable points only the throat and gills, the eyes, and the parts just under the pectoral fins. The tail is moderate in size and rounded, the longest rays a little above the middle, so that it is not quite symmetrical. Upon the hinder part of the back is the dorsal fin, and below the dorsal an anal fin, immediately in front of which is the vent or outlet of the alimentary canal. The paired fins, pectoral and ventral, occupy the places natural to them as representatives of the anterior and posterior limbs of salamanders and alligators.

The length of the head varies in the different species, but, whether longer or shorter, the jaws are furnished with rows of very sharp and closely-set teeth. The apparent form of these teeth is a simple elongated cone; but it has been shown by Prof. Jeffries Wyman that their surface is really deeply folded, so that a cross-section resembles that of the teeth of the curious fossil Batrachians, called, for that reason, Labyrinthodonts. The eyes are of moderate size. As with ordinary fishes, the ears do not appear externally. The nostrils are two pair of small holes at the tip of the snout, communicating with an olfactory sac on each side; the lining of this sac presents one median longitudinal and many transverse folds.

The genus *Lepidosteus*, according to Huxley, has not been found earlier than the Tertiary rocks; although the family *Lepidosteidæ* is represented by more or less numerous genera as far back as the Carboniferous and perhaps (by *Cheirolepis*) in the Devonian.

True gar-pikes are not found in Europe, Asia, Africa, or Australia, or in South America; while in North America they seem to be nearly confined to the Mississippi River and its tributaries, and the Great Lakes.[1]

Prof. Poey has also recorded the existence of a gar-pike in Cuba, a fact which is interesting, not as an indication of "manifest destiny," but as a memorial of the supposed ancient connection between the West India Islands and our continent. None have been found in salt-water, and the writer has no knowledge as to how far they enter the mixed water at the mouth of the Mississippi; but their tenacity of life encourages the belief that they might possibly adapt themselves to the ocean. Their introduction into New England waters would afford to Eastern zoölogists the much-desired opportunity of studying their development, of which nothing whatever is known.

We must now inquire whether there are more than one species of *Lepidosteus*.

Unfortunately, this question involves several others. For the genus *Lepidosteus*, established by Lacepede for the single species

[1] A few examples have been taken in Cayuga Lake, in Central New York, having probably entered by the canal at its northern end; it is said to occur in the Susquehanna River, Pennsylvania. It is lately reported that a species has been found in China.

osseus, has since been subdivided by some authors into *Lepidosteus*, *Cylindrosteus*, and *Litholepis*, or *Atractosteus*; and nearly forty specific names have been applied. One of these, *Sarchirus*, merely denotes the lobed state of the pectoral fin of the *young* gar (as will be shown further on), and most of the others seem to be based upon individual or geographical variations. Much more remains to be learned before the exact number of species can be ascertained; meantime, we may safely admit the three following:

L. osseus, the bony gar, having a long and narrow snout, and rarely attaining five feet in length; *L. platystomus*, the short-nosed gar, with a short and broad snout, as the name implies; and *L. adamantinus*, the alligator-gar or diamond-gar, with a short and wide snout, but attaining a greater size than the other two, and more common in the southern part of the Mississippi Valley. Probably the careful comparison of many individuals will oblige us to admit one or two additional species.

Notwithstanding, however, the peculiarities by which several of the species of *Lepidosteus* may be distinguished, so many and so obvious are the features which unite them together, and separate them from all other fishes, that they are recognized by all as belonging together, just as are the catfishes, the suckers, or the sturgeons.

Moreover, their internal structure, so far as it has been ascertained, presents a remarkable uniformity, whence we may infer that there is no important difference in their functions or habits, excepting in so far as may depend upon their circumstances, their food, etc. It is desirable to ascertain the extent of this variation, by accurate observation of carefully-determined examples, but on the present occasion we must be content, although unwillingly, with the assumption that what one gar has done another gar can do.[1]

Like most other New England zoölogists, the writer had been long obliged to content himself with dead gar-pikes, and with the somewhat unsatisfactory figures and descriptions which occur in a few zoölogical works. He had gained some more vivid impressions from the words and blackboard sketches of him who regarded "the establishment of the order of Ganoids as the most important advance which he had brought about in ichthyology."[2]

But even these privileges only increased the desire to behold the gar alive and active, and to realize the delight expressed by the great teacher when first enabled to observe them upon his journey to Lake Superior.

[1] Unwillingly, because all such assumptions are very undesirable. There have proved to be exceptions to nearly all general rules, whether of structure or of functions, as is shown in a paper by the writer, entitled "Is Nature inconsistent?"—(The *Galaxy*, April, 1876.)

[2] Although most other zoölogists have differed with Agassiz respecting the limits of the group, the name has been generally retained.

When, therefore, the writer found himself upon the Illinois River (at Peoria, Illinois), his steps almost instinctively sought the water, in the somewhat unreasonable expectation of being first greeted by a majestic "gar," rather than by some of the many kinds of ordinary fish so abundant in the Western rivers.

The first glance was disappointing. The river here widens into a basin known as Peoria Lake; and from the fishermen's pier, projecting some forty feet from the shore, could be seen no sign, near or remote, of the hoped-for mail-clad fish. The fishermen, who had not yet become acquainted with that unnatural perversity of naturalists which causes them to prize some things inversely as their beauty, their gentleness, and their commercial value, called attention to the "cats," "buffaloes," and other marketable fish swarming in the sunken pens, and promised to bring in some gars from their next haul; adding some emphatic statements as to the superabundance of these and of other such trash.

Just then, gliding slowly about very near the surface, and apparently undisturbed by the splashing of the bulky "cats" and "buffaloes," was seen a slender little fish less than three inches long. It was a young gar-pike. It might easily have escaped between the bars of the tanks, but instead remained within arm's-length of the edge of the open trap, moving gently to and fro as if courting observation.

A tin cup was anxiously brought: it was dipped into the water, slowly approached, and quickly lifted. The gar was there. But, floating as usual at the surface, a slight tilting of the cup spilt it back again into the water. To the astonishment of all, it soon reappeared in its former place, seeming actually to welcome death for the sake of (scientific) immortality.

By a second and more careful effort the young gar was secured, and soon transferred to the basin of water which was destined to be its home for three weeks.

During that time a part of each day was spent in observation of its form and its movements, and in comparing it with other gars, old and young.

Their Habits.—None of the young gars observed by the writer showed any disposition to attack each other or the small fishes placed with them; and the stomachs of the two adults examined with reference to this point contained only a few grasshoppers. But the many and sharp teeth are evidently well fitted for seizing living and active prey, and the fishermen accuse the gars of destroying large numbers of food-fishes. On this account, as also in revenge for the damage done by them when entangled in the nets, the fishermen are said to throw them out upon the bank to die, or to plunge them forcibly head first into the soft mud. More information is needed as to the food of the gar.

The following brief account of their manner of feeding is from a

report of some remarks of Prof. Agassiz on young, living gar-pikes from Lake Ontario, before the Boston Society of Natural History, in 1856:

"The manner of feeding also is unlike that of other fishes, and resembles that of reptiles. Other fishes take their food and swallow it at once, with open mouth. But this one (the young gar) approaches its prey (in this case small minnows) slyly, sidewise, and, suddenly seizing it, holds it in its jaws until, by a series of movements, it succeeds in getting it into a proper position for swallowing, as is the habit with lizards and alligators."

Before attaching much importance to the reptilian analogies here suggested, it should be ascertained whether the mode of swallowing above described is not followed by certain long-billed Teleosts (as *Belone*, etc.), and, on the other hand, discarded by the short-headed gar, whose jaws have nearly the form of the pickerel. Upon the whole, the gars and other typical Ganoids seem to have affinities with Batrachians rather than with scaly reptiles.

The flesh of the gar is soft, and speedily decays. In Wood's "Natural History," it is stated that "the flesh of the bony pike is said to be good;" and Prof. W. S. Barnard informs me that the gars, especially the young, are not infrequently used as food by whites in Wisconsin, and by both whites and negroes in Mississippi. Still, there is no reason for believing that the flesh is particularly desirable.

In this connection, it is worth noting that little use as food is made by man of the representatives of the Ganoids and the Plagiostomes, which, as shown by fossil remains, were created before the ordinary fishes. Some kinds of skates are eaten on the French coast, and sturgeons are known as "Albany beef," but no comparison can be made between them and the salmon, the cod, or the mackerel.

While watching the living gar, whether old or young, one of the first things noted is that it not only remains usually near the surface, but, at short intervals, actually protrudes the head from the water. In so doing, it turns partly over upon one side, emits a large bubble of air, executes a slight gulping movement of the jaws and throat, and sinks again below the surface; immediately afterward a few smaller bubbles escape from the gill-slit on each side of the neck. The foregoing is a very bald and inadequate description of a curious and, when first observed, astonishing operation. The movements are very rapid, and almost convulsive, as if the fish were suddenly oppressed by something, and hastened to remove it. The little gar first obtained almost invariably turned upon the left side, the air escaping from the right; this uniformity was not observed with the others. Occasionally they would open the jaws widely, as if gaping; and at other times the sides of the mouth were spread laterally.

With reference to the young gars from Lake Ontario already mentioned, Prof. Agassiz is reported as follows: "This fish is re-

markable for the large quantity of air which escapes from its mouth. The source of this air he has not been able to determine. At certain times it approaches the surface of the water, and seems to take in air, but he could not think that so large a quantity as is seen adhering in the form of bubbles to the sides of the gills could have been swallowed, nor could he suppose that it could be secreted by the gills themselves."

Since the exhalation of air from any source is evidently as easily performed below the surface, the periodical ascent of the gars goes far to show that there is likewise an inhalation. But as it was not easy to determine this, on account of the small size of the young gars and the difficulty of handling the older ones, the writer experimented upon another Western Ganoid, the *Amia*, or "mud-fish," or "dog-fish."

When placed in a tank the *Amia* kept near the bottom, and seemed to prefer the darker portions. But it came to the surface at pretty regular intervals, emitting one or two large bubbles from the mouth, and, on descending, several smaller ones from the opercular orifice.

The fish was gradually accustomed to having the body gently embraced by the hand about the middle.

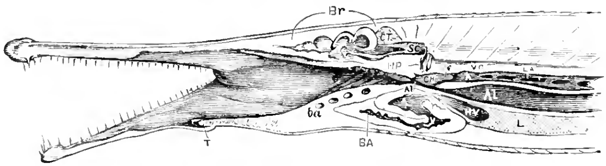


Fig. 4.—Vertical Longitudinal Section of the Head of *Lepidosteus platystomus*, One-half Natural Diameter.

Br, the brain cut on the median line so as to show the ventricles of the two hinder lobes, the cerebellum and optic lobes. *SC*, the spinal cord passing backward into the canal of the vertebral column (*VC*). *CT*, a mass of connective tissue filling the hinder part of the brain-cavity. *HP*, the right hypopharyngeal bone, just in front of the passage (*CH*) from the throat (*AT*) upward and backward into the air-bladder (*A*). *Ve* is a valve which seems to guard the opening from within; a corresponding valve is on the left side. *LA* is one of the openings from the median channel of the air-bladder into a lateral chamber. *L* is the liver, which terminates forward in a large blood-vessel, *HV*. *A* and *V* are the auricle and ventricle of the heart; *BA*, the branchial artery; and *ba*, the cut ends of the smaller arteries to the gills on the right side. *T* is the tongue.

Having been thus prepared, the fish was permitted to swim to and fro in the tank, but prevented from rising. It soon became uneasy, and, after a few not very violent efforts to disengage itself, emitted a large bubble of air.

Now, if this emission were all that was necessary we may suppose that it would have remained quiet for another period. On the contrary, after a second or two of repose (perhaps resulting from the habit of being satisfied after the respiratory act), the fish became more and more uneasy, moved rapidly to and fro, turned and twisted and lashed with its tail, and finally, by a violent effort, escaped from the hand. It rose to the surface, and, *without emitting any bubble, opened*

its jaws widely and apparently gulped in a large volume of air. It then descended and remained quiet for the usual interval.

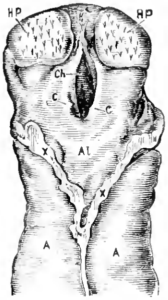


FIG. 5.—VIEW FROM BELOW OF THE UPPER OR DORSAL WALL OF THE THROAT OF THE LONG-NOSED GAR (*Lepidosteus osseus*), ONE-HALF NATURAL DIAMETER.

The œsophagus is removed excepting that part of the dorsal wall (*Al*) which is closely attached to the air-bladder (*A*). Its cut edges are indicated by *x x*. *Ch* is the opening or "chink" leading into the air-bladder, and *C C* indicate projecting points at the sides of the chink. *HP*, hypopharyngeal bones armed with teeth.

The escaping air should be chemically examined. But, so far as the experiments go, it seems probable that, with both *Amia* and *Lepidosteus*, there occurs an inhalation as well as exhalation of air at pretty regular intervals, the whole process resembling that of the *Menobranchus* and other salamanders, and the tadpoles, which, as the gills shrink and the lungs increase, come more frequently to the surface for air.

But the reader may say: "These fishes have gills, of course; but have they also lungs?" To this the answer is both yes and no; for there are at least two different ways of interpreting certain facts; and some definitions are not as yet wholly agreed upon.

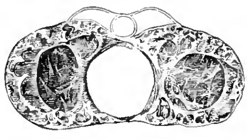


FIG. 6.—CROSS-SECTION OF THE AIR-BLADDER OF *L osseus*, ONE-HALF NATURAL DIAMETER.

The central open space is the median channel; on each side is seen one of the numerous subdivisions of the lateral portions of the air-bladder. Above are the median aorta and the two lateral veins, as in Fig. 3.

The facts are as follows: the *Lepidosteus* and *Amia*, like many other fishes, have an *air-bladder*—a sac lying under the spine and above the alimentary canal, and communicating by a slit-like orifice with the upper side of the throat. With sturgeons and catfishes and most common fishes, the sac is nearly or quite simple, and the communication with the throat may be very narrow or even closed Such fishes are not known to swallow air, and there is need of further information as to the composition and source of the contained gas. But the air-bladder of *Amia* and *Lepidosteus* is divided into many cells,

so as to resemble a frog's lungs; and the walls and partitions of these cells have many blood-vessels. These air-bladders are, in fact, more cellular and more vascular than the lungs of *Menobranchus*, or the hinder and larger portion of the lungs of serpents. And, in the light of the observations already recorded, there seems good reason for believing that pure air is inhaled and vitiated air exhaled whenever the fish rises to the surface.

It is worth noting, also, that both *Amia* and *Lepidosteus* are very tenacious of life, and endure removal from the water for a time much better than do the sturgeons, whose air-bladders are neither cellular nor vascular. The latter, also, are bottom-feeders, while the gars seem to keep near the surface of the water.

Why, then, are not these air-bladders lungs?

The most obvious objection is, that their openings are into the upper or dorsal side of the throat, while the glottis of batrachians, reptiles, birds, quadrupeds, and ourselves, communicates with the lower or ventral side.

This objection may be met in two ways. In the first place, if allowed, we should have to admit that all the so-called air-breathing vertebrates have organs (the lungs) which have no representative in the fishes, and that most of the latter have an organ (the air-bladder) which has no representative in the former.

It is true that some fishes have no air-bladder; but with some, as *Amphioxus*, the lamprey-eels, the sharks,[1] and the skates, we may infer that it has not yet become developed; while with others, as the flat fishes, the air-bladder may have been lost through what may be called a local retrograde metamorphosis.

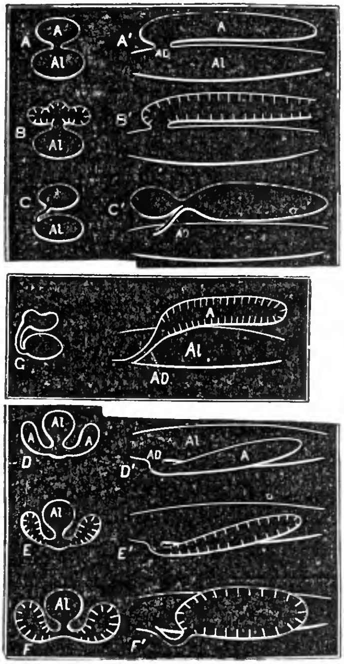
It is important to note, also, that an air-bladder and lungs have never been found in one and the same animal; and since arms, front-legs, flippers, and wings, are all regarded as modifications of the same organs, anterior limbs; and since, in many other cases, organs of very different size, form, complexity, and function, are considered as homologous, we shall be following precedent in admitting a willingness to regard air-bladders and lungs as modifications of the same organ.

But the true argument against the objection is derived from the existence of transition forms, or links, between air-bladders and lungs, as to the position of the organs themselves, and their communications with the alimentary canal.

With *Amia* and *Lepidosteus* the air-bladder and the opening of the duct are both dorsal. With the Brazilian fish called *Erythrinus* (as first stated by Johannes Müller, and lately verified by the writer), the duct opens upon one *side* of the throat. In the lately-discovered *Ceratodus* of Australia, as described by Günther, the sac and duct are single, but the former is vascular, and the latter enters at the left

[1] Maclay has figured a rudimentary air-bladder in certain shark-embryos.

of the ventral surface. With two African Ganoids, *Polypterus* and *Calamoichthys* (as also stated by Müller, and verified by the writer as to the latter genus) the sac is double, and communicates with the ventral side in the median line; but it is slightly cellular, as in *Menobranchus*.



A. Sturgeons and many Teleosts.

B. *Amia* and *Lepidosteus.*

C. *Erythrinus.*

G. *Ceratodus.*

D. *Polypterus, Calamoichthys.*

E. *Lepidosiren, Protopterus.*

F. Reptiles, birds, mammals.

FIG. 7.—DIAGRAMS REPRESENTING THE CONNECTION BETWEEN THE AIR-BLADDER OR LUNG AND THE ALIMENTARY CANAL IN CERTAIN VERTEBRATES.

Al, the alimentary canal. *A*, the air-bladder. *AD*, the air-duct.

The figures at the right show the alimentary canal and air-bladder from the left side; those at the left represent cross-sections more or less foreshortened in some cases.

A A′ represent the simple condition-connections of the air-bladder in the sturgeons (*Acipenser*) and in most Teleosts where the air duct remains open. *B B′* represent the arrangement in *Amia* and *Lepidosteus*, where the duct opens upon the dorsal side of the throat, but the bladder is more or less cellular. The hinder end of the bladder is left open to indicate its great length in *Lepidosteus*. In *C C′* is shown the arrangement in *Erythrinus*. The bladder is still upon the dorsal side, but the front part is separated from the hinder two-thirds by a constriction, and the long duct passes forward from just behind the constriction to enter the left side of the throat. There are fibrous partitions in part of the bladder, but I do not know that they are vascular. The condition in *Ceratodus* is shown at *G*; the bladder is single but vascular, and the duct opens on the ventral side, but not in the middle line.

In the remaining figures the air-duct opens on the lower or ventral surface of the throat, and the air-bladder is in two parts, which unite at the duct, but separate backward and lie upon the sides of the stomach, or even to some extent upon its dorsal surface next the backbone. In the side-views only the left sac is seen; in the cross-sections the whole is foreshortened so as to bring it into one plane. In *Polypterus* and *Calamoichthys* the inner surface of the sacs is nearly smooth, but in *Lepidosiren*, as in the salamanders, it is more or less folded and vascular, and is also connected with the heart by special vessels. In the reptiles, birds, and mammals, the duct or trachea soon divides into the two bronchial tubes.

Finally, in the "mud-fishes" of Africa and South America (*Protopterus* and *Lepidosiren*) the duct is ventral, and the air-bladder is a double and lung-like sac with stiff walls.

This series seems to connect the air-bladder of the fishes with the lungs of the true aërial vertebrates, and to remove the objection

based upon the different position of the communication between them and the alimentary canal.[1]

But another and perhaps more weighty objection has been urged by Prof. Huxley. He says: "But such air-sacs are air-bladders and not lungs, because they receive their blood from the adjacent arteries of the body, and not direct from the heart, while their efferent vessels are connected only with the veins of the general circulation."

According to this view, therefore, the Dipnoans (*Protopterus* and *Lepidosiren*) have lungs, because the blood goes to the air-sacs by a pulmonary artery, and returns by a pulmonary vein into a left auricle; while the cellular and vascular air-bladders of *Amia* and *Lepidosteus* are not lungs, because such an arrangement does not exist.

Yet Prof. Huxley applies the name *placenta* to the vascular interdigitations by which the young of some sharks are connected with the mother, although they are developed from the yolk and not, as in mammals, from the chorion. It would be interesting to know whether the *nerves* of the air-bladder are the same as those of the lungs.

The best test of the naturalness of the definition would be furnished by the discovery of some form having the pulmonary vessels connected with an air-bladder lying upon the dorsal side of the alimentary canal. Meantime, since all are agreed upon the facts, the question concerns interpretations and definitions.

Whether or not the air-bladder of the gar-pike is entitled to the name of lung, we may admit that it corresponds with a lung in its essential connection with the alimentary canal, and apparently in its function as an organ for aiding the oxygenation of the blood.

MESMERISM, ODYLISM, TABLE-TURNING, AND SPIRITUALISM.[2]

By WILLIAM B. CARPENTER, C. B., M. D., LL. D., F. R. S.

I.

THE aphorism that "history repeats itself" is in no case more true than in regard to the subject on which I am now to address you. For there has been a continuity from the very earliest times of a belief, more or less general, in the existence of "occult" agencies, capable of manifesting themselves in the production of mysterious phenomena,

[1] In fact, considering the resemblance of the brains and enameled scales of *Lepidosteus* and *Polypterus*, and the differences of their air-bladders and ducts, one is inclined to regard the latter as of slight taxonomic importance.

[2] This discussion, in which the subjects are considered historically and scientifically, is an expansion of the lectures delivered at the London Institution.

of which ordinary experience does not furnish the *rationale.* And while this very continuity is maintained by some to be an evidence of the real existence of such agencies, it will be my purpose to show you that it proves nothing more than the wide-spread diffusion, alike among minds of the highest and of the lowest culture, of certain tendencies to thought, which have either created ideal marvels possessing no foundation whatever in fact, or have by exaggeration and distortion invested with a preternatural character occurrences which are perfectly capable of a natural explanation. Thus, to go no further back than the first century of the Christian era, we find the most wonderful narrations, alike in the writings of pagan and Christian historians, of the doings of the Eastern "sorcerers" and Jewish "exorcists" who had spread themselves over the Roman Empire. Among these the Simon Magus slightly mentioned in the book of Acts was one of the most conspicuous, being recorded to have gained so great a repute for his "magic arts" as to have been summoned to Rome by Nero to exhibit them before him; and a Christian father goes on to tell how, when Simon was borne aloft through the air in a winged chariot in the sight of the emperor, the united prayers of the apostles Peter and Paul, prevailing over the demoniacal agencies that sustained him, brought him precipitately to the ground. In our own day, not only are we seriously assured by a nobleman of high scientific attainments that he himself saw Mr. Home sailing in the air, by moonlight, out of one window and in at another, at a height of seventy feet from the ground; but eleven persons unite in declaring that Mrs. Guppy was not only conveyed through the air in a trance all the way from Highbury Park to Lamb's Conduit Street, but was brought by invisible agency into a room of which the doors and windows were closed and fastened, coming "plump down" in a state of complete unconsciousness and partial deshabille upon a table, round which they were sitting in the dark, shoulder to shoulder.

Of course, if you accept the testimony of these witnesses to the aërial flights of Mr. Home and Mrs. Guppy, you can have no reason whatever for refusing credit to the historic evidence of the demoniacal elevation of Simon Magus, and the victory obtained over his demons by the two apostles. And you are still more bound to accept the solemnly-attested proofs recorded in the proceedings of our law courts within the last two hundred years, of the aërial transport of witches to attend their demoniacal festivities; the belief in witchcraft being then accepted not only by the ignorant vulgar, but by some of the wisest men of the time, such as Lord Bacon and Sir Matthew Hale, Bishop Jewell, Richard Baxter, Sir Thomas Browne, and Addison, while the denial of it was considered as virtual atheism.

The general progress of rationalism, however, as Mr. Lecky has well shown, has changed all this; and to accept any of these marvels we must place ourselves in the mental attitude of the narrator of Mrs.

Guppy's flight, who glories in being so completely unfettered by scientific prejudices as to be free to swallow anything, however preposterous and impossible in the estimation of scientific men, that his belief in "spiritual" agencies may lead him to expect as probable.

If time permitted, it would be my endeavor to show you, by an historical examination of these marvels, that there has been a long succession of epidemic delusions, the form of which has changed from time to time, while their essential nature has remained the same throughout; and that the condition which underlies them all is *the subjection of the mind to a dominant idea.* There is a constitutional tendency in many minds to be seized by some strange notion which takes entire possession of them; so that all the actions of the individual thus "possessed" are results of its operation. This notion may be of a nature purely intellectual, or it may be one that strongly interests the feelings. It may be confined to a small group of individuals, or it may spread through vast multitudes. Such delusions are most tyrannous and most liable to spread when connected with religious enthusiasm: as we see in the dancing and flagellant manias of the middle ages; the supposed demoniacal possession that afterward became common in the nunneries of France and Germany; the ecstatic revelations of Catholic and Protestant visionaries; the strange performances of the Convulsionnaires of St.-Médard, which have been since almost paralleled at Methodist "revivals" and camp-meetings; the preaching epidemic of Lutheran Sweden, and many other outbreaks of a nature more or less similar. But it is characteristic of some of the later forms of these epidemic delusions that they have connected themselves rather with science than with religion. In fact, just as the performances of Eastern magi took the strongest hold of the Roman mind when its faith in its old religious beliefs was shaken to its foundations, so did the grandiose pretensions of Mesmer—who claimed the discovery of a new force in Nature, as universal as gravitation, and more mysterious in its effects than electricity and magnetism—find the most ready welcome among skeptical votaries of novelty who paved the way for the French Revolution; and this pseudo-scientific idea gave the general direction to the doctrines taught by Mesmer's successors, until, in the supposed "spiritualistic" manifestations, a recurrence to the religious form took place, which, I think, may be mainly traced to the emotional longing for some assurance of the continued existence of departed friends, and hence of our own future existence, which the intellectual loosening of time-honored beliefs as to the immortality of the soul has brought into doubt with many.

I must limit myself, however, to this later phase of the history, and shall endeavor to show you how completely the extravagant pretensions of mesmerism and odylism have been disproved by scientific investigation; all that is genuine in their phenomena having been accounted for by well-ascertained physiological principles; while the

evidence of their higher marvels has invariably broken down when submitted to the searching tests imposed by the trained experts whom I maintain to be alone qualified to pronounce judgment upon the matter.

Nothing is more common than to hear it asserted that these are subjects which any person of ordinary intelligence can investigate for himself. But the chemist and the physicist would most assuredly demur to any such assumption in regard to a chemical or physical inquiry; the physiologist and geologist would make the same protest against the judgment of unskilled persons in questions of physiology and geology; and a study of mesmerism, odylism, and spiritualism, extending over more than forty years, may be thought to justify me in contending that a knowledge of the physiology and pathology of the human mind, of its extraordinary tendency to self-deception in regard to matters in which its feelings are interested, of its liability to place undue confidence in persons having an interest in deceiving, and of the modes in which fallacies are best to be detected and frauds exposed, is an indispensable qualification both for the discrimination of the genuine from the false, and for the reduction of the genuine to its true shape and proportions.

And I further hold, not only that it is quite legitimate for the inquirer to enter upon this study with that "prepossession" in favor of the ascertained and universally admitted laws of Nature which believers in spiritualism make it a reproach against men of science that they entertain, but also that experience proves that a prepossession in favor of some "occult" agency is almost sure to lead the investigator to the too ready acceptance of evidence of its operation. I would be the last to affirm that there is not "much more in heaven and earth than is known to our philosophy;" and would be among the first to welcome any addition to our real knowledge of the great agencies of Nature. But my contention is, that no new principle of action has any claim to scientific acceptance, save upon evidence as complete and satisfactory as that which would be required in any other scientific investigation.

The recent history of Mr. Crookes's most admirable invention, the radiometer, is pregnant with lessons on this point. When this was first exhibited to the admiring gaze of the large body of scientific men assembled at the *soirée* of the Royal Society, there was probably no one who was not ready to believe with its inventor that the driving round of its vanes was effected by *light;* and the eminent physicists in whose judgment the greatest confidence was placed, seemed to have no doubt that this mechanical agency was something outside optics properly so called, and was, in fact, if not a new force in Nature, a new *modus operandi* of a force previously known under another form. There was here, then, a perfect readiness to admit a novelty which seemed so unmistakably demonstrated, though transcending all previ-

ous experience. But after some little time the question was raised whether the effect was not really due to action of *heat* upon the attenuated vapor of which it was impossible entirely to get rid; and the result of a most careful and elaborate experimental inquiry, in which Nature has been put to the question in every conceivable mode, has been to make it, I believe, almost if not quite certain that the first view was incorrect, and that heat is the real moving power, acting under peculiar conditions, but in no new mode.

No examination of the phenomena of spiritualism can give the least satisfaction to the mind trained in philosophical habits of thought, unless it shall have been, in its way, as searching and complete as this. And when scientific men are invited to dark *séances*, or admitted only under the condition that they shall merely look on and not inquire too closely, they feel that the matter is one with which they are entirely precluded from dealing. When, again, having seen what appears to them to present the character of a very transparent conjuring trick, they ask for a repetition of it under test-conditions admitted to be fair, their usual experience is that they wait in vain (for hours it may be) for such repetition, and are then told that they have brought an "atmosphere of incredulity" with them, which prevents the manifestation. Now, I by no means affirm that the claims of spiritualism are *dis*proved by these failures; but I do contend that, until the evidence advanced by believers in those claims has stood the test of the same sifting and cross-examination by skeptical experts that would be applied in the case of any other scientific inquiry, it has no claim upon general acceptance; and I shall now proceed to justify that contention by an appeal to the history of previous inquiries of the like kind.

It was about the year 1772 that Mesmer, who had previously published a dissertation "On the Influence of the Planets on the Human Body," announced his discovery of a universal fluid, "the immediate agent of all the phenomena of Nature, in which life originates, and by which it is preserved;" and asserted that he had further discovered the power of regulating the operations of this fluid, to guide its currents in healthy channels, and to obliterate by its means the tracks of disease. This power he in the first instance professed to guide by the use of magnets; but having quarreled with Father Hell, a Professor of Astronomy at Vienna, who had furnished him with the magnets with which he made his experiments, and who then claimed the discovery of their curative agency, Mesmer went on to assert that he could concentrate the power in and liberate it from any substance he pleased, could charge jars with it (as with electricity) and discharge them at his pleasure, and could cure by its means the most intractable diseases. Having created a great sensation in Bavaria and Switzerland by his mysterious manipulations, and by the novel effects which they often produced, Mesmer returned to Vienna, and undertook to cure

of complete blindness a celebrated singer, Mademoiselle Paradis, who had been for ten years unsuccessfully treated by the court physician. His claim to a partial success, however, which was in the first instance supported by his patient, seemed to have been afterward so completely disproved by careful trials of her visual powers, that he found himself obliged to quit Vienna abruptly, and thence proceeded to Paris, where he soon produced a great sensation. The state of French society at that time, as I have already remarked, was peculiarly favorable to his pretensions. A feverish excitability prevailed, which caused the public mind to be violently agitated by every question which it took up. And Mesmer soon found it advantageous to challenge the learned societies of the capital to enter the lists against him; the storm of opposition which he thus provoked having the effect of bringing over to his side a large number of devoted disciples and ardent partisans. He professed to distribute the magnetic fluid to his congregated patients from a *baquet* or magnetic tub which he had impregnated with it, each individual holding a rod which proceeded from the *baquet;* but when the case was particularly interesting, or likely to be particularly profitable, he took it in hand for personal magnetization. All the surroundings were such as to favor, in the hysterical subjects who constituted the great bulk of his patients, the nervous paroxysm termed the "crisis," which was at once recognized by medical men as only a modified form of what is commonly known as an "hysteric fit;" the influence of the imitative tendency being manifested as it is in cases where such fits run through a school, nunnery, factory, or revivalist-meeting, in which a number of suitable subjects are collected together. And it was chiefly on account of the moral disorders to which Mesmer's proceedings seemed likely to give rise that the French Government directed a scientific commission, including the most eminent *savants* of the time—such as Lavoisier, Bailly, and Benjamin Franklin—to inquire into them. After careful investigation they came to the conclusion that there was no evidence whatever of any special agency proceeding from the *baquet;* for not only were they unable to detect the passage of any influence from it that was appreciable, either by electric, magnetic, or chemical tests, or by the evidence of any of their senses; but, on blindfolding those who seemed to be most susceptible to its supposed influence, all its ordinary effects were produced when they were without any connection with it, *but believed that it existed.* And so, when in a garden of which certain trees had been magnetized, the patients, either when blindfolded, or when ignorant which trees had been magnetized, would be thrown into a convulsive fit if they believed themselves to be near a magnetized tree, but were really at a distance from it; while, conversely, no effect would follow their close proximity to one of these trees when they believed themselves to be at a distance from any of them. Further, the commissioners reported that, although some cures might be wrought by the mesmeric

treatment, it was not without danger, since the convulsions excited were often violent and exceedingly apt to spread, especially among men feeble in body and weak in mind, and almost universally among women; and they dwelt strongly also on the moral dangers which, as their inquiries showed, attended these practices.

Now, this report, although referring to a form of mesmeric procedure which has long since passed into disrepute, really deals with what I hold to be an important principle of action, which, long vaguely recognized under the term "imagination," now takes a definite rank in physiological science; namely, that in individuals of that excitable nervous temperament which is known as "hysterical" (a temperament by no means confined to women, but rare in healthy and vigorous men), the expectation of a certain result is often sufficient to evoke it. Of the influence of this "expectancy" in producing most remarkable changes in the bodily organism, either curative or morbid, the history of medicine affords abundant and varied illustrations; and I shall presently show you that it operates no less remarkably in calling forth movements which, not being consciously directed by the person who executes them, have been attributed to hypothetical occult agencies.

I shall not trace the further history of Mesmer, or of the system advocated by himself; contenting myself with one ludicrous example of the absurdity of his pretensions. When asked in his old age by one of his disciples why he ordered his patients to bathe in river-water in preference to well-water, he replied that it was because river-water is exposed to the sun's rays; and when further asked how these affected it in any other way than by the warmth they excited, he replied, "Dear doctor, the reason why all water exposed to the rays of the sun is superior to all other water is because it is magnetized—since twenty years ago *I magnetized the sun!*"

In the hands of some of his pupils, however, animal magnetism, or Mesmerism (as it gradually came to be generally called), assumed an entirely new development. It was discovered by the Marquis de Puysegur, a great landed proprietor, who appears to have practised the art most disinterestedly for the sole benefit of his tenantry and poor neighbors, that a state of profound insensibility might be induced by very simple methods in some individuals, and a state akin to somnambulism in others; and this discovery was taken up and brought into vogue by numerous mesmerizers in France and Germany, while, during the long Continental war, and for some time afterward, it remained almost unknown in England. Attention seems to have been first drawn to it in this country by the publication of the account of a severe operation performed in 1829, by M. Cloquet, one of the most eminent surgeons of Paris, on a female patient who had been thrown by mesmerism into the state of somnambulism; in which, though able to converse with those around her, she showed herself entirely insen-

sible to pain, while of all that took place in it she had subsequently no recollection whatever. About twelve years afterward, two amputations were performed in our own country—one in Nottinghamshire, and the other in Leicestershire—upon mesmerized patients, who showed no other sign of consciousness than an almost inaudible moaning; both of them exhibiting an uninterrupted placidity of countenance, and declaring, when brought back to their ordinary state, that they were utterly unaware of what had been done to them during their sleep. And not long afterward Dr. Esdaile, a surgeon in Calcutta, gave details of numerous most severe and tedious operations performed by him, without the infliction of pain, upon natives in whom he had induced the mesmeric sleep—the rank of presidency surgeon being conferred upon him by Lord Dalhousie (then Governor-General of India), "in acknowledgment of the services he had rendered to humanity." The results of minor experiments performed by various persons, desirous of testing the reality of this state, were quite in harmony with these. Writing in 1845, Dr. Noble, of Manchester (with whom I was early brought into association by Sir John Forbes in the pursuit of this inquiry), said:

> "We have seen a needle thrust deeply under the nail of a woman sleeping mesmerically, without its exciting a quiver; we have seen pungent snuff in large quantities passed up the nostrils under the same circumstances, without any sneezing being produced until the patient was roused, many minutes afterward; we have noticed an immunity from all shock when percussion-caps have been discharged suddenly and loudly close to the ear; and we have observed a patient's little-finger in the flame of a candle, and yet no indication of pain. In this latter case all idea of there having been courageous dissimulation was removed from our mind in seeing the same patient afterward evince both surprise and indignation at the treatment received; as, from particular circumstances, a substantial inconvenience was to result from the injury to the finger, which was by no means slight." [1]

This "mesmeric sleep" corresponds precisely in character with what is known in medicine as "hysteric coma;" the insensibility being as profound, while it lasts, as in the coma of narcotic poisoning or pressure on the brain; but coming on and passing off with such suddenness as to show that it is dependent upon some transient condition of the sensorium, which, with our present knowledge, we can pretty certainly assign to a reduction in the supply of blood caused by a sort of spasmodic contraction of the blood-vessels. That there is no adequate ground for regarding it as otherwise than *real*, appears further from the discovery made not long afterward by Mr. Braid, a surgeon practising at Manchester, that he could induce it by a very simple method, which is not only even more effective than the "passes" of the mesmerizer, but is, moreover, quite independent of any other will than that of the person who subjects himself to it. He found that

[1] *British and Foreign Medical Review*, April, 1845.

this state (which he designated as hypnotism) could be induced in a large proportion of individuals of either sex, and of all ranks, ages, and temperaments, who determinately fix their gaze for several minutes consecutively on an object brought so near to their eyes as to require a degree of convergence of their axes that is maintainable only by a strong effort.[1]

The first state thus induced is usually one of profound comatose sleep; the "subject" not being capable of being roused by sensory impressions of any ordinary kind, and bearing without the least indication of consciousness what would ordinarily produce intolerable uneasiness or even severe pain. But, after some little time, this state very commonly passes into one of somnambulism, which again corresponds closely on the one hand with *natural*, and on the other with *mesmeric*, somnambulism. In fact, it has been by the study of the somnambulism artificially induced by Mr. Braid's process that the essential nature of this condition has been elucidated, and that a scientific *rationale* can now be given of a large proportion of the phenomena reported by mesmerizers as having been presented by their somnambules.

It has been claimed for certain mesmeric somnambules, however, that they occasionally possess an intelligence altogether superhuman as to things present, past, and future, which has received the designation "lucidity;" and it is contended that the testimony on which we accept the reality of phenomena which are conformable to our scientific experience ought to satisfy us equally as to the genuineness of those designated as "the higher," which not only transcend but absolutely contradict what the mass of enlightened men would regard as universal experience. This contention, however, seems to me to rest upon an entirely incorrect appreciation of the probative force of evidence; for, as I shall endeavor to prove to you in my succeeding lecture, the only secure basis for our belief on *any* subject is the confirmation afforded to external testimony by our sense of the inherent probability of the fact testified to; so that, as has been well remarked, "evidence tendered in support of what is new must correspond in strength with the degree of its incompatibility with doctrines generally admitted as true; and, where statements obviously contravene all past experience

[1] Mr. Braid's peculiar success in inducing this state seemed to depend partly upon his mode of working his method, and partly upon the "expectancy" of his subjects. Finding a bright object preferable, he usually employed his silver lancet-case, which he held in the first place at ordinary reading-distance, rather above the plane of the eyes; he then slowly approximated it toward the middle point, a little above the bridge of the nose, keeping his own eyes steadily fixed upon those of his "subject," and watching carefully the direction of their axes. If he perceived their convergence to be at all relaxed, he withdrew the object until the axes were both again directed to it; and then again approximated it as closely as was compatible with their continued convergence. When this could be maintained for a sufficient length of time upon an object at no more than about three inches' distance, the comatose state generally supervened.

and the universal consent of mankind, any evidence is inadequate to the proof, which is not complete, beyond suspicion, and absolutely incapable of being explained away."

Putting aside for the present the discussion of these asserted marvels, I shall try to set before you briefly the essential characters which distinguish the state of somnambulism (whether natural or acquired) on the one hand from dreaming, and on the other from the ordinary waking condition. As in both these, the mind is in a state of activity; but, as in dreaming, its activity is free from that controlling power of the will by which it is directed in the waking state; and is also removed from this last by the complete ignorance of all that has passed in it, which is manifested by the "subject" when called back to his waking self, although the events of one access of this "second consciousness" may vividly present themselves in the next, as if they had happened only just before. Again, instead of all the senses being shut up, as in ordinary dreaming sleep, some of them are not only awake, but preternaturally impressible; so that the course of the somnambulist's thought may be completely directed by suggestions of any kind that can be conveyed from without through the sense-channels which still remain open. But, further, while the mind of the ordinary dreamer can no more produce movements in his body than his impressions on sense-organs can affect his mind, that of the somnambulist retains full direction of his body (in so far, at least, as his senses serve to guide its movements); so that he *acts* his dreams as if they were his waking thoughts. The mesmerized or hypnotized somnambule may, in fact, be characterized as a *conscious automaton*, which, by appropriate suggestions, may be made to think, feel, say, or do, almost anything that its director wills it to think, feel, say, or do; with this remarkable peculiarity, that its whole power seems concentrated upon the state of activity in which it is at each moment, so that every faculty it is capable of exerting may become extraordinarily intensified. Thus, while vision is usually suspended, the senses of hearing, smell, and touch, with the muscular sense, are often preternaturally acute, in consequence, it would seem, of the undistracted concentration of the attention on their indications. I could give you many curious instances of this, which I have myself witnessed, as also of the great exertion of muscular power by subjects of extremely feeble *physique;* but as they are all obviously referable to this one simple principle, I need not dwell on their details, preferring to narrate one which I did not myself witness, but which was reported to me on most trustworthy authority, of a remarkable manifestation of a power of imitative vocalization that is ordinarily attainable only after long practice. When Jenny Lind was singing at Manchester, she was invited by Mr. Braid to hear the performances of one of his hypnotized subjects, an illiterate factory-girl, who had an excellent voice and ear, but whose musical powers had received scarcely any cultivation. This girl, in the hyp-

notic state, followed the Swedish nightingale's songs in different languages both instantaneously and correctly; and when, in order to test her powers, Mademoiselle Lind extemporized a long and elaborate chromatic exercise, she imitated this with no less precision, though unable in her waking state even to attempt anything of the sort. Now, I wish you to compare this case with another, which was reported about the same time upon what seemed equally unexceptionable testimony. When Miss Martineau first avowed her conversion to mesmerism, the extraordinary performances of her servant J—— were much talked of; and, among other marvels, it was asserted that she could converse, when in her mesmeric state, in languages she had never learned, and of which she knew nothing when awake—the particular fact being explicitly stated that Lord Morpeth had tested this power and had found it real. Now, you will readily perceive that, supposing the testimony in these two cases to have been exactly the same, its probative force would have been very different. For the first of them, though unprecedented, presented no scientific improbability to those who were prepared, by their careful study of the phenomena of hypnotism, to believe that the power of imitative vocalization, like any other, might be intensified by the concentration of the "subject's" whole attention upon the performance. But it seemed inconceivable that an uneducated servant-girl could understand what was said to her in a language she had never learned; still more, that she should be able to reply in the same language. And the only possible explanation of the fact, *if fact it was*, short of a miracle, may have lain either in her having learned the language long before and subsequently forgotten it, or in her being able by "thought-reading" (which is maintained by some, even at the present time, to be one of the attributes of the mesmeric state) to divine and express the answer expected by Lord Morpeth. But the marvel was entirely dissipated by the inquiries of Dr. Noble, who, being very desirous of getting at the exact truth, first applied for information to a near relative of Miss Martineau, and was told by him that the report was not *quite* accurate; for, on Lord Morpeth putting a question to J—— in a foreign language, J—— had replied appropriately in her own vernacular. Her comprehension of Lord Morpeth's question, however, appeared in itself sufficiently strange to be suggestive of some fallacy; and having an opportunity not long afterward of asking Lord Morpeth himself what was the real state of the case, Dr. Noble learned from him that when he put a question to J—— in a foreign language she imitated his speech after a fashion by an unmeaning articulation of sound.

On the lesson which this case affords as to the credibility of testimony in regard to what are called the "higher phenomena" of mesmerism, I shall enlarge in my succeeding lecture, and at present I shall only remark that it was shown by careful comparison between the phenomena displayed by the same individuals, when "mesmerized"

in the ordinary way, and "hypnotized" by Mr. Braid's process, that there was no other difference between the two states than that arising from the special *rapport* between the mesmerizer and his subject; and that this was clearly explicable by the "expectancy" under which the "subject" passed into the state of second consciousness. For Mr. Braid found himself able, by assuring his "subjects" during the induction of the coma, that they would hear the voice of one particular person and no other, to establish this *rapport* with any person he might choose; the case being strictly analogous to the awaking of the telegraph-clerk by the clicking of his needles, of the doctor by his night-bell, or of the mother by her infant's cry, though all would sleep soundly through far louder noises to which they felt no call to attend. And thus, as was pointed out long since by Dr. Noble and myself, not only may the general reality of the mesmeric somnambulism be fully admitted, but a scientific *rationale* may be found for its supposed distinctive peculiarities, without the assumption of any special "magnetic" or "mesmeric" agency.

It is affirmed, however, that proof of this agency is furnished by the power of the "silent will" of the mesmerizer to induce the sleep in "subjects" who are not in the least aware that it is being exerted; and, further, to direct from a distance the actions of the somnambule. Doubtless, if satisfactory proof of this assertion could be furnished, it would go far to establish the claim. But nothing is more difficult than to eliminate all sources of fallacy in this matter. For while it is admitted by mesmerizers that the belief that the influence is being exerted is quite sufficient in habitual somnambules to induce the result, it is equally certain that such "sensitives" are marvelously quick at guessing from slight intimations what is expected to happen. And it has been repeatedly found that mesmerizers who had no hesitation in asserting that they could send particular "subjects" to sleep, or could affect them in other ways, by an effort of silent will, have utterly failed to do so when these subjects were carefully kept from any suspicion that such will was being exerted. Thus, Dr. Noble has recorded the case of a friend of his own, who, believing himself able thus to influence a female servant whom he had repeatedly mesmerized, accepted with the full assurance of confident faith a proposal to make this experiment in Dr. Noble's house instead of his own. The girl, having been sent thither with a note, was told to sit down in Dr. Noble's consulting-room while the answer was being written; her chair being close to a partially-open door, on the other side of which her master, whom she supposed to be elsewhere, had previously taken up his position. Although this gentleman had usually found two or three minutes sufficient to send the girl to sleep when he was in his own drawing-room and she was in the kitchen, the two being separated by intervening walls and flooring, yet when he put forth his whole force for a quarter of an hour within two feet of her, with only a partially-closed door

between them, it was entirely without result; and no other reason for the failure could be assigned than her entire freedom from expectancy. So, in another case, in which Mr. Lewis (accounted one of the most powerful mesmerists of his time) undertook to direct the actions of his somnambule in the next room, according to a programme agreed on between himself and one set of witnesses, while the actions actually performed were recorded and timed by another set, there was found to be so complete a discordance between the programme "willed" and the actions really executed as entirely to negative the idea of any dependence of the latter upon the directing power of the mesmerizer—the supposed relation having obviously grown up under the habitual repetition of a certain succession of performances (such as I had myself frequently witnessed), which the somnambule supposed himself expected to go through in the same order.[1] A converse experiment, performed by Dr. Elliotson himself, satisfied him that expectancy would take the place of what he maintained to be the real mesmeric influence. Having told one of his *habituées* that he would go into the next room and mesmerize her through the door, he retired, shut the door, performed no mesmeric passes, but tried to forget her, walked away from the door, busied himself with something else, and even walked into a third room; and, on returning in less than ten minutes, found the girl in her usual sleep-waking condition. The extreme susceptibility of many of these "sensitive" subjects further accounts for their being affected (without any intentional deceit) by physical impressions which are quite imperceptible to others: such as slight differences in temperature, when two coins are presented to them, of which one has been held in the hand of the mesmerizer; or two wineglasses of water, into one of which he has dipped his finger for a short time. But the *belief* that he has transmitted his influence in any mode is quite sufficient to produce the result, as was shown in an amusing case recorded by M. Bertrand, whose treatise on "Animal Magnetism" (Paris, 1826) is by far the most philosophical work extant on the subject. Having occasion to go a journey of a hundred leagues, leaving a female somnambule under the treatment of one of his friends, M. Bertrand sent him a magnetized letter, which he requested him to place on the stomach of the patient, who had been led to anticipate the expected results—mesmeric sleep, with the customary phenomena, supervened. He then wrote another letter which he did *not* magnetize, and sent it to her in the same manner, and with the same intimation. She again fell into the mesmeric sleep, which was attributed to the letter having been unintentionally impregnated by

[1] Mr. Lewis was challenged to this test-experiment, in consequence of his assertion that he had repeatedly induced the mesmeric sleep, and had directed the operations of his somnambules, by the exertion of his "silent will," from a distance. His utter failure to produce either result, however, under the scrutiny of skeptical inquirers, obviously discredits all his previous statements, except to such as are ready to accept without question the slenderest evidence of the greatest marvels.

M. Bertrand with the mesmeric fluid while he was writing it. Desiring to test the matter still further, he caused one of his friends to write a similar letter, imitating his handwriting so closely that those who received it should believe it to be his—the same effect was once more produced.

And so it was with the large number of experiments that were made within my own knowledge during the twenty years' attention that I gave to this subject, with a view to test the mesmerizer's power of inducing any of the phenomena of this state without the patient's consciousness. Successes, it is true, were not unfrequent; but these almost invariably occurred when the experiments were made under conditions to which the parties had become habituated, as in the case of Dr. Noble's friend. For his performances were so continually being repeated to satisfy the curiosity of visitors, that Dr. Noble's call at his house would have been sufficient to excite, on the part of the "subject," the expectancy that would have thrown her into the sleep. But when such expectancy was carefully guarded against, the result was so constantly negative as—I will not say to *disprove* the existence of any special mesmeric force, but to neutralize completely the affirmative value of the evidence adduced to *prove* it. For I think you must now agree with me that, if "expectancy" alone is competent to produce the results, as admitted by the most intelligent mesmerizers, nothing but the most rigid exclusion of such expectancy can afford the least ground for the assumption of any other agency. And my own prolonged study of the subject further justifies me in taking the position that it is only when the inquiry is directed, and its results recorded, by *skeptical experts*, that such results have the least claim to scientific value. The disposition to overlook sources of fallacy, to magnify trivialities into marvels, to construct circumstantial myths (as in the case of Miss Martineau's J—— and Lord Morpeth) on the slightest foundation of fact, and to allow themselves to be imposed upon by cunning cheats, has been so constantly exhibited by even the most honest believers in the "occult" power of mesmerism, as, not only in my own opinion, but in that of my very able allies in this inquiry, to deprive the unconfirmed testimony of any number of such believers, in regard to matters lying beyond scientific experience, of all claim to acceptance. In fact, the positions taken in regard to mesmerism by my friend Dr. Noble, as far back as 1845,[1] and more fully developed by myself a few years later on the basis of Mr. Braid's experiments, and of my own physiological and psychological studies,[2] have not only in our own judgment, but by the general verdict of the medical and scientific world, been fully confirmed by the subsequent course of events, the history of which I shall next proceed to sketch. —*Fraser's Magazine.*

[1] *British and Foreign Medical Review*, vol. xix.

[2] "Principles of Human Physiology," fourth edition, 1853; and *Quarterly Review*, October, 1853.

AQUEDUCTS.

THE remains of the lofty arcades upon which the aqueducts of ancient Rome were carried to the city have been justly classed among the finest and most picturesque ruins of the Roman Empire. Stretching across the plain eastward of the city, and towering high above the landscape, they are the first objects to fix the gaze and command the admiration of the stranger approaching the home of the Cæsars, and to fill his mind with visions of the strength and grandeur of the nation which mastered the world two thousand years ago. But these ruins speak not only of the mechanical skill and physical greatness of that vanished people, but also of their refinement and their acquaintance with the deeply-hidden laws of hygiene; for they well knew what has become known to us only after a lapse of twenty centuries, after the measurement of the heavens, and the discovery of the steam-engine, that for every large city an abundant supply of pure, fresh water is indispensable to the preservation of health. At the zenith of her grandeur, Rome had eleven distinct aqueducts, whose aggregate discharge was equivalent to a stream twenty feet wide by six deep, with a fall six times as rapid as that of the river Thames. The daily supply was in the proportion of 332 gallons to each inhabitant, and it was distributed to the palaces and humbler dwellings in every part of the city, as well as to innumerable fountains, many public wells and large reservoirs, to the numerous baths, and to several artificial lakes, where the emperors held their *naumachiæ*, or sham naval battles. These eleven constituted the most extensive and perfect system of aqueducts that has been possessed by any city even up to the present time. Their combined length was over 300 miles, 50 of which were above-ground either upon low substructures or more imposing arcades. The loftiest arcade was that belonging to the *Aqua Claudia* and the *Anio Novus*; it was in one place 109 feet high.[1] In respect to height of arcades, however, the aqueducts of Rome were less remarkable than several built by the emperors, about the same time, for certain provincial cities of the empire, and others of more recent times. Thus the Emperor Agrippa built an aqueduct for the city of Nemausus (Nîmes) in France, and carried it across the river Gard upon an arcade 180 feet high, and about 900 feet long. This splendid structure, still perfect, is now called the *Pont du Gard*, and is an object of attraction and astonishment to modern travelers. It consists of a triple row of arches, which in the two lower tiers are of wide span, and in the upper one narrow. This arcade "has no rival for lightness and boldness of

[1] The Roman foot was 11.6496 English inches; 5 feet made one passus; 1,000 passus one mile, or 1,618 English yards.

design among the existing remains of works of this class carried out by the ancient Romans." It is constructed entirely of freestone, to the covering of the upper row of arches. The stones were laid without cement, and each was raised by the lewis, the holes in which it was inserted being still visible exactly over the centre of gravity in every stone. Still more remarkable for height is one of the bridges of the aqueduct of Antioch, also built by the Romans. It is 700 feet long and 200 feet high. The lower part consists of a solid wall pierced by two arches, in the centre—one upon the ground, the other directly above. Along the top is a row of narrow arches. The design and workmanship of this structure are very rude. But in later times arcades of even greater height have been built. The arcade Delle Torri, near Spoleto, built in the seventh or eighth century A. D., is about 300 feet high and over 700 long. It consists of ten arches between lofty columns, and is remarkable as an early example of the pointed arch, as well as for lightness of design. The arcade of the Roquefavour Aqueduct across the river Arc is 262 feet high, and 1,287 feet long. This aqueduct supplies the city of Marseilles with water from the river Durance, 51 miles distant. It was constructed between 1839 and 1847, and has eight and a half miles of tunnels passing through three chains of limestone mountains. But the most imposing arcade in the world, as regards the combined effect of height and length, is that of Maintenon. It is about five-sixths of a mile long, and over 200 feet high. Louis XIV. built it for an aqueduct he projected to convey the water of the Eure from Pont Gouin to Versailles, a distance of about 33 miles. This great enterprise was abandoned in 1688, after an expenditure of four years and 22,000,000 francs. The design contemplated one arcade over three miles long, which in its highest part was to have been formed of three tiers of arches.

At the time that it was built, the Anio Novus, probably of all aqueducts in the world, drew its water from the most distant source. True, the conduit of the Aqua Marcia, one of the most important of the aqueducts of Rome, was longer, but its source was only 39 miles from the city, while that of the Anio was 42; the conduit of the one was 61 miles and 710 paces long, of the other 58 miles and 700 paces. There are at Carthage the remains of an aqueduct which is said to have been over 50 miles long, but it is impossible to tell whether it was built by the Carthaginians proper, or by the Romans who, long after the destruction of the old city, founded a new one on its ruins. The accompanying cut represents the remains, near Undena, of one of the arcades of this aqueduct. It comprised 1,000 arches, many of which were over 100 feet high. The ancient Peruvians are said to have built the most remarkable aqueducts in the world for length. Garcilasso speaks of one that was 360 miles long, and another 450, but these were for irrigating purposes, and they wound around the mountains and followed the surface of the valleys instead of crossing

them on arcades, and therefore differed essentially from the aqueducts that we have been considering. And, besides, the statements as to their length should not be received without caution, for, at the time that the Spaniards first visited the country, their belief in the marvelous had been very greatly enlarged by the discovery of a new world.

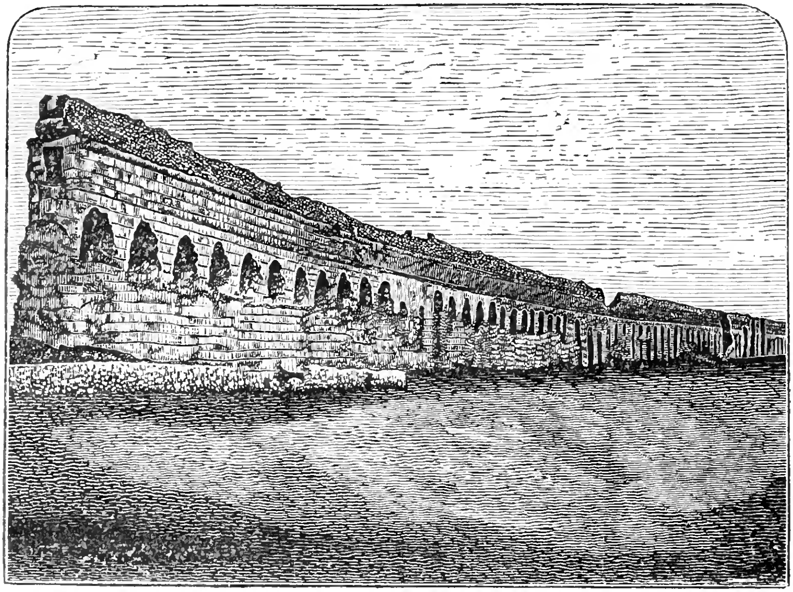


FIG. 1.—THE AQUEDUCTS. The Crossing in the Campagna near the Piscinæ and Roma Vecchia.

The longest aqueduct proper is that now building to convey the waters of the Somme-Soude, Soudon, and Dhuis, to Paris. It will be about 110 English miles long. The aqueduct of Roquefavour, already referred to, is 60 miles long, the longest in actual use.

The Romans appear to have got their knowledge of aqueduct-building, like most of their other knowledge, from the Greeks; for, while their first aqueduct, the *Aqua Appia*, was not constructed until 441 years after the building of the city, or 312 B. C., the Greeks had built aqueducts at Megara and Samos as early as 625 B. C., and at Athens in 560 B. C. But there is this difference, that the Greeks did not use arcades, which, however, were not rendered necessary by the topography of the country. At Samos, a tunnel four-fifths of a mile long, eight feet high and eight wide, was cut through a hill between the city and the water-source. A channel three feet wide was built within the tunnel, and an opening of the same width made to the surface from end to end, so that the fresh air came in contact with the water, which flowed into a conduit of masonry at the lower end, and thence directly to the baths, fountains, etc., of the city. This work

was constructed by Eupalinus, who had previously gained celebrity by building the aqueduct at Megara. At Athens the water-supply was drawn by subterranean conduits from Mounts Hymettus, Pentelicus, and Parnes, and received into reservoirs outside the city. Two conduits came from Mount Hymettus, and passed under the bed of the river Ilissus. Of course, it was necessary to supply fresh air to the water flowing through these subterranean channels, and that was done by piercing them with shafts at intervals of about fifty yards. Subterranean channels were also used to distribute the water through the city; they were of different forms, being round or square, and in some of them pipes of baked clay were laid. It is somewhat remarkable that these beneficent works were constructed by the wisdom of rulers who have come down to us branded as tyrants. The tyrants Theagenes of Megara, Polycrates of Samos, and Pisistratus of Athens, were the men who caused them to be built. Some of those old aqueducts still continue to supply Athens with water. The aqueduct of Syracuse which still supplies the city with an abundance of water, and which is remarkable for having a tunnel under the sea, between the city and the mainland, was built some time prior to the Athenian invasion, 412 B. C., for Thucydides mentions that it was partially destroyed by the invaders. But far more ancient than any yet referred to is the one at Jerusalem, built by Solomon, to conduct the water from the reservoirs, or "pools," that bear his name, to the city, a distance of six miles. It was formed by an earthen pipe ten inches in diameter, incased in stone and laid underground. It is still in use.

The periodical overflow of the Nile, the Tigris, and Euphrates, enabled the peoples of Egypt and Babylonia to store up vast quantities of water in artificial lakes, of which the Mœris in Egypt is a celebrated example, and the water was utilized as required, by surface-conduits or canals.

Let us now turn back to the aqueducts of Rome, and examine somewhat the details of construction. A recently-published work on the aqueducts comprehended in the archæology of Rome, by John Henry Parker, C. B., affords much interesting information in this connection. The facts are ascertained partly from the work of Sextus Julius Frontinus, who was superintendent of the aqueducts (*curator aquarum*) under the Emperors Nerva and Trajan (A. D. 94–107), and partly from explorations of the courses and remains of the aqueducts made by Mr. Parker himself. Of the eleven aqueducts already referred to, ten approached the city from the east and one from the west. Of the ten on the east, four had their sources near Subiaco, in a spur of the Apennines beyond Tivoli; the others took their rise in the lower lands nearer Rome. Two of these, the *Anio Vetus* and the *Anio Novus*, were fed by the river Anio, as is indicated by their names; the others received their waters from springs or small lakes,

and were called after their builders or projectors. The waters of the Marcian, the most prized for their purity and coldness, were collected from several springs. For the Anio Novus, which was unfailing as well as the most abundant of the aqueducts, the river Anio was arrested near its source by three gigantic walls at different levels, and formed into as many lakes, one below the other. Over these walls the waste-water fell in magnificent cascades, one of them over 150 feet high. The object of the lakes was to clarify the water; for the Anio, though usually a limpid stream, is liable to become muddy after a heavy rain. The sources of the Anio Novus and the Aqua Claudia are over 2,000 feet above the level of the city, and those of the Marcia and Anio Vetus are not very much lower. Descending from such a height and for distances varying in direct lines from 30 to 43 miles, the water would naturally acquire great velocity and tremendous force, which it was necessary to diminish, and that was done by making numerous angles in the conduits. The angles were made generally at every half-mile, and were points at which reservoirs (*castella*), or filtering-places (*piscinæ*), or both, with accompanying air-shafts, were built. These were surmounted by small towers. As an additional means of breaking the force of the water, the bottoms of the conduits were given a succession of short undulations. The conduits, reservoirs, and filtering-places, were lined with a cement called *opus signinum*, which is so compact that it will resist a hard tool. The art of making it has been lost. The conduits, always covered, were carried on arcades only where it was necessary to cross a valley or a plain above its level; for the rest of their way they ran in places upon the surface of the ground, but mostly below it. Thus of the 58 miles of the Anio Novus, 49 were underground. No two aqueducts were on the same level, and so, where their courses converged, it was both possible and convenient to carry one conduit upon another, because it was forbidden by law to erect a building within a certain number of feet on either side of an aqueduct; hence we find the Aquæ Marcia, Tepula, and Julia, carried from their point of convergence one above the other on one arcade, and the Aqua Claudia and Anio Novus on another. Each of the conduits was differently shaped, some having arched, others angular roofs. Besides the small reservoirs referred to as occurring at the angles of the conduits, there were larger ones at longer intervals. The ruins of one of these, belonging to the Aqua Marcia, are still to be seen near Carciano. It is a huge subterranean chamber divided by an arcade in the middle. Between five and seven miles from Rome were the great filtering-places to which most of the aqueducts converged. The waters, however, were not mingled, for each aqueduct had its separate chambers, though it was always within the power of the attendants (*aquarii*) to turn the water from one aqueduct into another at will. Of these

filtering-places, those of the Claudia and Anio Novus were underground, and now appear simply as mounds. The others were aboveground, but covered over. From this point two magnificent arcades, the Marcian and the Claudian, extended to the city—the one carrying three aqueducts, the other two. They were not more than 100 yards apart, and the Marcian was 30 feet high, the Claudian 50. The filtering-places were of peculiar construction and admirable design. They consisted of four chambers, two on a level with the conduit, and two directly below (Fig. 2). The water flowing into the first descended

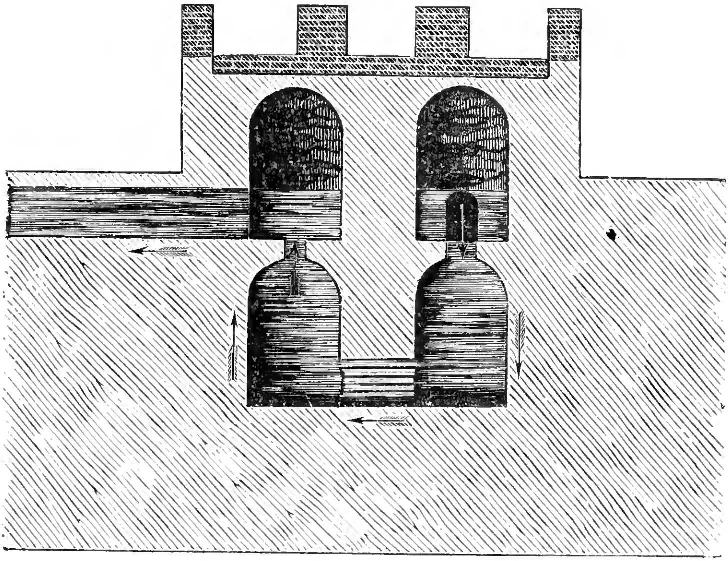


Fig. 2.—Section of the Piscina of the Anio Novus, at the Entrance into Rome in a Tower of the Wall of Aurelian and of the Gardens of the Sessorian Palace.

through an opening in the floor to the second, whence it flowed on through a perforated wall or grating to the third, ascending from that through an opening in the roof to the fourth, where it found its original level and reëntered the conduit. A stairway descending to an opening afforded access into the chambers beneath, and by the assistance of sluice-gates the water could be turned directly from the first chamber into the fourth, so that the mud could be cleaned out of the chambers below. It is remarkable that this ingenious device for filtering has not occurred to modern aqueduct-builders, for its simplicity and utility are conspicuous.

The details of distribution are interesting, but we have not space to go far into them. There were 247 main reservoirs in the city, from which the water was distributed to 19 barracks for the use of the army, 95 public establishments, 39 theatres and places of amusement, and 591 open reservoirs for the public. That was in the time of

Frontinus. The number of open reservoirs was afterward increased. Heavy penalties were inflicted for dipping a dirty vessel into one of these reservoirs. Of the total supply, a little over one-third was given to the public, and the remainder divided pretty evenly between private and imperial purposes. The wealthy had water brought into reservoirs within the courts of their residences, whence it was raised to the upper stories in buckets worked by windlasses. This method of supplying the upper stories is in use at the present time. The Romans had no pumps. Why the water was not conveyed upward in pipes does not appear, except that in regard to the more elevated parts of the city it was probably not brought in at a high enough level. They possessed lead pipes of different sizes, and stopcocks of bronze and silver, for these have been found in various places; and that they were perfectly familiar with the principle of hydraulics, that water may be returned to its original level, is proved not only by the construction of the filtering-places already described, but also by the fact that they actually applied the principle on a stupendous scale. Besides, there is a work of Vitruvius extant which recognizes and gives directions for conveying water on this principle. An aqueduct constructed by the Emperor Claudius, for the ancient city of Lugdunum (now Lyons), possessed two inverted siphons, by which the water was carried across deep valleys. There is no doubt that they were acquainted, too, with the poisonous action of lead on water; but, if that deterred them from raising the water, it shows they were more careful in guarding against unhealthful influences than we moderns are, for lead pipes are in general use to distribute water through our houses to-day.

The aqueducts were placed under the care of a *curator aquarum*, and afterward, in the time of Diocletian, under several magistrates, called *consulares aquarum*. The actual attendants numbered 700, and were divided into the *familia publica* and the *familia Cæsaris*. The former, 240 in number, were paid by the state; the latter, 460, by the emperor. With regard to the cost of building the aqueducts, it seems to have been defrayed, in the majority of cases, out of government funds; but it is recorded in an inscription on the Porta Maggiore, a gate of the city over which the conduits of the Claudia and Anio Novus were carried, that those two aqueducts were built by the Emperor Claudius at his own expense. This gate affords a clew to the reason why arcades instead of solid walls were used to carry the aqueducts across the plains: it was not solely for economy's sake, nor for beauty's; but while those considerations, no doubt, were entertained, the main object was, to avoid interference with the freedom of travel.

The aqueducts were all destroyed in the Gothic wars under Vitiges and Totila, but the most important of them were restored either by Belisarius or Narses. These, however, fell gradually into decay, and ultimately became useless. Pope Paul III. (1540) restored to use the

aqueduct on the west side of Rome; and Sixtus V. (1585) restored the aqueduct of Trajan by mistake for the Marcian. These two, the former called Paola, and the latter Felice, continued to be the only means of supply until 1870, when the real Marcian was restored by a company of Englishmen and Romans. The water is brought as far as Tivoli in a stone conduit, and the rest of the way in cast-iron pipes. It has sufficient pressure to supply the tops of all the houses.

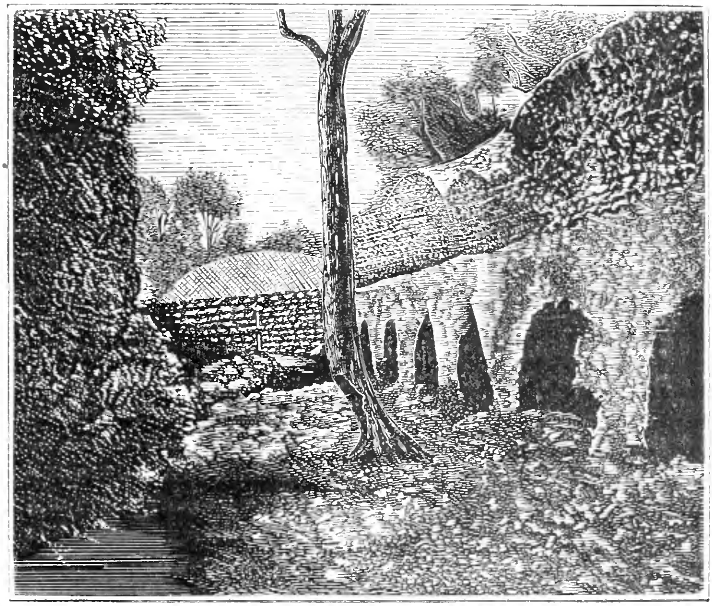


FIG. 3.—RESERVOIR OF AQUA MARCIA. (Interior.)

Reference has been made to the aqueduct now building for Paris. The supply of water required is 22,000,000 gallons per day, and the aqueduct was designed to convey that quantity. It is intended for household use only, the existing supply, which is abundant for other purposes, having become somewhat polluted. It was calculated that the aggregate yield of the three rivers which are to be turned to account would be 28,000,000 gallons per day; but subsequent observation has shown that in very dry seasons it falls considerably below the quantity required. It was therefore found necessary to sink wells or shafts into the chalky formation in which the rivers have their rise, to artificially increase the supply. The plan comprises conduits for collecting the waters from the several sources called "conduits of derivation," and a main aqueduct to which these converge. The former are together about 50 English miles long, and the latter is 110. The main aqueduct has a fall of $73\frac{2}{3}$ feet, and terminates in service-reservoirs at Belleville $83\frac{2}{3}$ feet above the level of the city. Along

the course of the main and subsidiary conduits are 17 bridges, $3\frac{3}{4}$ miles of arcade, $4\frac{1}{3}$ miles of siphon, and $17\frac{1}{3}$ miles of tunnel. The work is done under the direction and supervision and in accordance with the designs of M. Belgrand. The total estimated cost, including $900,000 paid for injury to riparian rights, is $5,200,000.

The aqueduct which supplies the city of Manchester (England) with water is remarkable for its system of impounding reservoirs, comprising seven, with dams varying from 70 to 100 feet in height. The work was begun in 1848, and had not been completed in 1874, although it was far enough advanced to supply the city with water. The city of Glasgow is supplied by the Loch Katrine Aqueduct, 35 miles long, which conveys the water of the famous lake of that name. It consists of a conduit of masonry 8 feet deep, 8 wide, and 27 miles long, and two lines of cast-iron pipes, between the city and the service-reservoirs, 8 miles long. The conduit between Loch Katrine and the service-reservoirs is for the most part a tunnel through solid rock. It crosses some ravines on stone or iron arcades, and others by siphons. It is capable of discharging 50,000,000 gallons per day. It was opened by the queen with appropriate ceremonies in October, 1859. The work was begun in 1855, and finished in 1860. The cost, exclusive of facilities for distribution, was $3,340,000.

In the autumn of 1873 was finished the aqueduct designed by Herr Carl Junker, of Vienna, and constructed by Mr. Antonio Gabrielli, of London, to convey the water of two springs (the Kaiserbrunn and Stixenstein), situated at the foot of the Styrian Alps, to Vienna, a distance of $56\frac{1}{2}$ miles. The conduit, which varies in size from $4\frac{1}{2} \times 2\frac{1}{2}$ feet to $6\frac{1}{2} \times 4$ feet, and is faced with polished cement, to facilitate the flow of the water, is always six feet below the surface of the earth or embankment through which it is carried. The object aimed at is to keep the water cold in summer and from freezing in winter. It has several splendid arcades, chief among which are one at Baden, another at Mödling, and a third at Liesing. The former is 96 feet high, about 2,000 feet long, and comprises 43 arches. The aqueduct delivers about 20,000,000 gallons a day. It was begun in 1869, and its cost was $10,000,000.

But, in regard to water-supply, the Roquefavour Aqueduct, referred to previously, is by long odds the most remarkable. The conduit is 7 feet deep, 30 wide at the top, and 10 at the bottom. It discharges 11 tons of water per second, or about 285,000,000 gallons per day. The water is used for the city of Marseilles, and to irrigate 25,000 acres around it.

In our own country there are several noted aqueducts—as the Cochituate at Boston, the Washington Aqueduct, and Croton at New York. The method employed by the cities of Chicago and Milwaukee to obtain their water-supply is unique. The water of Lake Michigan is brought into the city by a tunnel from a sufficient distance off

to insure its being pure, and is then pumped up into service-reservoirs, whence it is distributed in the usual manner. The Chicago tunnel is three miles long, that of Milwaukee is shorter.

The Washington Aqueduct leads from a reservoir which impounds the river-water at the Potomac Falls, is 16 miles long, and supplies the cities of Washington and Georgetown. Its capacity is 70,000,000 gallons per day. The water is conveyed in a brick-and-rubble masonry conduit, of circular form, to the service-reservoir five miles from the city, and the rest of the way in three large cast-iron pipes capable of delivering 30,000,000 gallons per day. This aqueduct was constructed at the expense of the United States Government, and cost \$3,000,000. It has several fine bridges, of which the most notable is the one across Cabin John Creek. This is a single granite arch, 100 feet high and 220 long. Another remarkable example of the wide, single arch occurs on the Lisbon Aqueduct, finished in 1738. It is 115 feet wide and 250 high.

By far the finest aqueduct in America is the Croton. This was begun in 1837, and finished in 1842, at a cost of \$8,575,000, without the means of distribution, which cost \$1,800,000 more. The length of conduit from the impounding to the receiving-reservoirs in Central Park is 38¼ miles, for 33 of which the conduit is built of stone, brick, and cement, arched above and below, 8 feet 5 inches high, 6¼ feet wide at the bottom, and 7⅔ at the top. The water crosses Harlem River in two cast-iron pipes 3 feet in diameter, and one wrought-iron pipe 7 feet 6 inches in diameter, laid upon High Bridge, a magnificent granite arcade 1,460 feet long and 114 high. It comprises 15 arches, 7 of which have 50 feet span, and 8, those over the river, 80 feet. The fall is 1.10 foot per mile, the velocity of the water 1½ mile an hour, and the possible discharge 115,000,000 gallons per day.

For the first six years after the completion of the aqueduct, the quantity of water used was only 18,000,000 gallons per day, but it has now increased to over 88,000,000. The supply is drawn from Croton River, a small stream that flows into the Hudson, a short distance above Sing Sing. The river was arrested by a dam 40 feet high, and made to form what is now called Croton Lake. The mouth of the aqueduct is 12 feet below the surface of the lake, whereby it is protected from freezing up in winter, and the water is obtained pure and cool in summer. The lake has an area of 400 acres, and usually affords a daily supply of 50,000,000 gallons; but this fell off, during a severe drought seven or eight years ago, to only 27,000,000, and since then another source has been added by damming up the western branch of Croton River. The receiving-reservoirs, two in number, are located in Central Park: the "old" covers 35 acres, and holds 150,000,000 gallons; the "new" covers 100 acres, and holds 1,030,000,000. The distributing-reservoir is situated 2¼ miles farther down, between Fifth

and Sixth Avenues, Fortieth and Forty-second Streets. Its walls are 45 feet high, and they inclose a little more than 4 acres. The water is brought down in five lines of iron pipe, two of which are 30 inches in diameter, two three feet, and one four feet. The distributing-pipes, ramifying throughout the city, are about 340 miles long. The "mains" are laid near the sidewalks on either side of the streets, and at every crossing are provided with branches for supplying the adjacent buildings. These branches are provided with stopcocks for turning off the water when necessary. The higher parts of the city lying north of Manhattan Valley are supplied from a tower and reservoir recently built on high ground near One Hundred and Seventy-third Street and Tenth Avenue, to which the water is raised by powerful pumps. The reader will have been struck with the similarity between this aqueduct and those of ancient Rome; it remains to be shown that there is one other point of resemblance, in the air-shafts that are built at intervals of a mile. They rise 14 feet above the ground, and, like the old Roman ones, are in the form of towers. Every third one is provided with a door and way of access into the conduit. But the conduit is without the filtering-places and the angles. The conduit does, indeed, make several curves of 500 feet radius, but these are for changing the course of the aqueduct to avoid obstacles, instead of for breaking the force of the water, which in fact is unnecessary, the inclination being, as already shown, insignificant. The level of Croton Lake is about 115 feet above that of Manhattan Valley, and when the old reservoir in Central Park was yet building, the citizens of New York were afforded the magnificent spectacle of a vertical column of water shooting up over 100 feet from the bottom of the valley.

In connection with our subject, though not strictly belonging to it, may be mentioned the fact that canals are in many places carried across valleys and rivers upon bridges. Examples have long existed on the Languedoc Canal in France. The first in England was the Barton Bridge, which carries a canal across the river Irwell 39 feet above the surface. It was constructed by Brindley, for the Duke of Bridgewater. Says a contemporary English writer: "It was commenced in September, 1760; and in July of the following year the spectacle was first presented, in this country, of vessels floating and sailing across the course of the river, while others in the river itself were passing under them." The Lancaster Canal has one of five arches of 72 feet span each, and 65 feet high, across the river Lune. Later and more celebrated examples, though, are those of Pont-y-Cysylte and Chirk in Wales. The former, constructed by Mr. Telford, "is justly celebrated for its magnitude, simplicity of desgin, and skillful disposition of parts, combining lightness with strength in a degree seldom attempted. It consists of cast-iron arches resting on pillars of stone; the length is 1,000 feet, the number of arches 19, and the height 126 feet." In this country these bridges are numerous, there being

no less than 32 on the Erie Canal. The finest of them are two across the Mohawk River, a third at Richmond over the Seneca River, and a fourth across the Genesee at Rochester. The latter is a splendid stone arcade 920 feet long, having six cut-stone arches of 52 feet span. A wire suspension-bridge of seven spans, each 160 feet long, conveys the Pennsylvania Canal across the Alleghany River at Pittsburg.

GRAVITATION, AND HOW IT WORKS.

By GRANVILLE F. FOSTER.

"The force of gravity acts on bodies directly in proportion to the quantity of matter in each."

"The force of gravity decreases in the reciprocal proportion of the square of the distance."—(Orr's "Circle of the Sciences," vol. vi., p. 1.)

AMONG students of natural philosophy no facts are more frequently misunderstood than those pertaining to the laws of gravitation. It is readily admitted that if a body A exerts on B a certain force of attraction, if A's mass be doubled, then will A's attractive influence on B be doubled also, but the fact is not so apparent that any two bodies, whatever their disparity of mass, or however great their distance apart, will attract each other with *precisely* equal forces; and that if, for instance, the mass of A be doubled, not only will A's attraction for B be doubled, but at the same time B's attraction for A will be doubled also. The pen I hold in my hand attracts the sun with precisely the same amount of force that the sun attracts the pen, and, if either the mass of the pen or sun be doubled, the *mutual* attraction will be doubled also. The first law of gravitation most certainly teaches that the earth, so insignificantly small as compared with the sun, both in volume and mass, attracts the sun with a force exactly equal to that which, being by the sun exerted on itself, reduces it to obedience, and compels it to make its annual revolution. So, too, the moon and the earth mutually and equally attract each other.

The fact that the forces of attraction between two bodies are equal may be easily explained as follows: Let there be five bodies, A, B, C, D, E, and let A be so situated as to be at equal distances from the other four: then it is evident that the forces which measure the mutual attractions of (A and B), (A and C), (A and D), and (A and E), are equal. Calling the force which A exerts on B, or B exerts on A, *one*, then will the sum of the forces which B, C, D, and E exert on A be equal to *four*, but the sum of A's attractions for B, C, D, and E, will also be equal to *four*, since A's attraction for B is in no way

either increased or diminished by the fact that at the same time it also exerts an attraction on C, D, or E. Now, let B, C, D, and E, be united into one mass, F, and it will be readily perceived that the truth of the foregoing statements cannot thereby be affected.

As a general formula the law of gravitation may be enunciated as follows: "If one of the masses contain m units of mass, and the other *one* unit, the force will be m times as great as though they were both units of mass; but if the second body contain n units of mass, the attraction will be n times as great as before; that is, $m\ n$ divided by the square of the distance between the bodies."

Now, suppose A and F free to move, then on meeting A will have moved over four-fifths of the distance between A and F, and F during the same time will have moved over one-fifth of the same distance; that is to say, the velocity of A has just been equal to four times that of F, and this is just what might have been expected from what is known of the laws of force. Suppose A and F to be placed where friction and other obstacles to motion do not exist, the velocities of the bodies will be indirectly as their masses, if the respective forces exerted on the bodies be equal; that is, a force which would propel a body with a certain velocity would propel another body one-quarter of the mass of the former with four times the velocity. In the case supposed, since A is one-quarter of the mass of F, a given force *must* necessarily move A over four times the space and with four times the velocity that it is able to move F, and when A and F meet the momenta of A and F will be respectively equal.

The truth that two bodies mutually and equally attract each other is also abundantly proved in astronomy. Take the case of the earth and moon. The earth by its attraction compels the moon to make around it as a centre her monthly revolution; but it is equally true that the moon compels the earth to move around the centre of gravity of the earth and moon, which centre, on account of the earth's mass being over eighty times that of the moon, is distant from the earth's centre a little over 2,000 miles, and this motion of the earth is performed in precisely the time of the lunar revolution, namely $27\frac{1}{3}$ days. Now, it will require but little reflection to perceive that to move the earth in a circle with a radius of a little more than 2,000 miles, and the moon in a circle with a radius of nearly 240,000 miles, would require equal forces. The same thing is true of the sun, which is obliged by the combined forces of the planets to revolve around the centre of gravity of the solar system, and on making the necessary calculations we find that the force exerted on the planets by the sun just equals the force exerted by the planets on the sun.

Weight has been defined as the measure of the earth's attraction. A body weighing one pound attracts the earth and is attracted by it with a force of one pound, but the same body at the sun's surface would attract the mass of the sun with a force of twenty-seven pounds,

since its weight has been increased twenty-seven times by the sun's attraction.

We have hitherto considered the *mutual* attraction of *two* bodies, but now let a third be introduced, as, for instance, in the case of A and F, let G be placed at equal distances from A and F, and let the relative masses of A and F be as stated before in this paper: then will the force which measures the *mutual* attraction of F and G be equal to four times the force which measures the *mutual* attraction of G and A, or, in other words, F will attract G with four times the force that A will attract G. Lastly, let G's mass equal A's mass, and let G be placed at double the distance from F that A has been placed: then, according to the second law of gravitation, the units of force which measure the *mutual* attraction of A and F will be four times the force which measures the mutual attraction of G and F.

ON THE HABITS OF ANTS.

By SIR JOHN LUBBOCK, Bart.

THE anthropoid apes no doubt approach nearer to man in bodily structure than do any other animals; but when we consider the habits of ants, their social organization, their large communities, elaborate habitations, their roadways, their possession of domestic animals, and even in some cases of slaves, it must be admitted that they have a fair claim to rank next to man in the scale of intelligence. They present, moreover, not only a most interesting but also a very extensive field of study. In this country we have nearly thirty species; but ants become more numerous, in species as well as individuals, in warmer countries, and more than seven hundred kinds are known. Even this large number certainly is far short of those actually in existence.

I have kept in captivity nearly half of our British species of ants, and at the present moment have in my room more than thirty nests, belonging to about twenty species, some of which, however, are not English. No two species are identical in habits, and on various accounts their mode of life is far from easy to unravel. In the first place most of their time is passed underground; all the education of the young, for instance, is carried on in the dark. Again, ants are essentially gregarious; it is in some cases difficult to keep a few alive by themselves in captivity, and at any rate their habits under such circumstances are entirely altered. If, on the other hand, a whole community is kept, then the greater number introduces a fresh element of difficulty and complexity. Moreover, within the same species, the individuals seem to differ in character, and even the same individual

will behave very differently under different circumstances. Although, then, ants have attracted the attention of many naturalists—Gould, De Geer, Swammerdam, Latreille, Leeuwenhoeck, Huber—and have recently been the object of interesting observations by Frederick Smith, Belt, Moggridge, Bates, Mayr, Emery, Forel, and others, they still present one of the most promising fields for observation and experiment.

The larvæ of ants, like those of bees and wasps, are small, white, legless grubs, somewhat conical in form, being narrower toward the head. They are carefully tended and fed, being carried about from chamber to chamber by the workers, probably in order to secure the most suitable amount of warmth and moisture. I have observed also that they are very often sorted according to age. It is sometimes very curious in my nests to see them divided into groups according to size, so that they remind one of a school divided into five or six classes. When full grown they turn into pupæ, sometimes naked, sometimes covered with a silken cocoon, constituting the so-called "ant-eggs." After remaining some days in this state, they emerge as perfect insects. In many cases, however, they would perish in the attempt, if they were not assisted, and it is very pretty to see the older ants helping them to extricate themselves, carefully unfolding their legs and smoothing out the wings, with truly feminine tenderness and delicacy.

Under ordinary circumstances an ants' nest, like a beehive, consists of three kinds of individuals: workers, or imperfect females (which constitute the great majority), males, and perfect females. There are, however, often several females in an ants' nest; while, as we all know, there is never more than one queen in a hive. The queens have wings, but after a single flight they tear off their own wings, and do not again quit the nest. In addition to the ordinary workers there is in some species a second, or rather a third, form of female. In almost any ants' nest we may see that the workers differ more or less in size. The amount of difference, however, depends upon the species. In *Lasius niger*, the small brown garden ant, the workers are, for instance, much more uniform than in the little yellow meadow ant, or in *Atta barbara*, where some of them are more than twice as large as others. But in certain ants there are differences still more remarkable. Thus, in a Mexican species, besides the common workers, which have the form of ordinary neuter ants, there are certain others in which the abdomen is swollen into an immense sub-diaphanous sphere. These individuals are very inactive, and principally occupied in elaborating a kind of honey.[1] In the genus *Pheidole*—very common in Southern Europe—there are also two distinct forms without any intermediate gradations: one with heads of the usual proportion, and a second with immense heads provided

[1] Westwood, "Modern Classification of Insects," vol. ii., p. 225.

with very large jaws. These latter are generally supposed to act as soldiers, and the size of the head enables the muscles which move the jaws to be of unusual dimensions, though the little ones are also very pugnacious. This differentiation of certain individuals so as to adapt them to special functions seems to me very remarkable; for it must be remembered that the difference is not one of age or sex.

The food of ants consists of insects—great numbers of which they destroy—of honey, honey-dew, and fruit; indeed, scarcely any animal or sweet substance comes amiss to them. Some species—such, for instance, as the small brown garden ant—ascend bushes in search of aphides. The ant then taps the aphis gently with her antennæ, and the aphis emits a drop of sweet fluid, which the ant drinks. Sometimes the ants even build covered ways up to and over the aphides, which, moreover, they protect from the attacks of other insects. Our English ants do not collect provision for the winter—indeed, their food is not of a nature which would admit of this. Some southern species, however, collect grain, occasionally in considerable quantities. Moreover, though our English ants cannot be said exactly to lay up stores, some at least do take steps to provide themselves with food in the future. The small yellow meadow ant (*Lasius flavus*), for instance, lives principally on the honey-dew of certain aphides which suck the roots of grass. The ants collect the aphides in the nest, not only watching over them themselves, but, as I have been able to satisfy myself, even over their eggs—an act which one is much tempted to refer to forethought, and which in such a case implies a degree of prudence superior to that of some savages. Besides these aphides, many other insects live in ants' nests. If they are to be regarded as domestic animals, then ants have more domestic animals than we have. The majority of these ant-guests are beetles. Some of them—as, for instance, the curious little *Claviger*—are quite blind, and are only found in ants' nests, the ant taking just as much care of them as of their own young. It is evident, therefore, that in some way they are useful or agreeable to the ants. The subject, however, is one as yet but little understood, and very difficult to study. Grimm and Lespés consider that some of these beetles secrete a sweet fluid like the aphides, and from analogy this seems probable. Other creatures which habitually live in ants' nests, like the little *Beckia albinos* or the blind woodlouse (*Platyarthrus*), perhaps make themselves useful as scavengers.

Nor are ants without their enemies. In addition to birds and other larger foes, if you disturb a nest of the brown ants at any time during the summer, you will probably see some very small flies hovering over them, and every now and then making a dash at some particular ant. These flies belong to the genus *Phora*, and to a species hitherto unnamed, which Mr. Verrall has been good enough to describe for me. They lay their eggs on the ants, inside which

the larvæ live. Other species of the genus are in the same way parasitic on bees. On the 14th of October last I observed that one of my ants had a mite attached to the underside of its head. The mite, which is still in the same position, is almost as large as the head. The ant cannot remove it herself. She has never come out of the nest, so that I could not do it for her, and none of her own companions from that day to this have thought of performing this kind office.

In character the different species of ants differ very much from one another. *F. fusca*, the one which is preëminently the enslaved ant, is, as might be expected, extremely timid; while the nearly allied *F. cinerea* has, on the contrary, a considerable amount of individual audacity. *F. rufa*, the horse ant, according to M. Forel, is especially characterized by the want of individual initiative, and always moves in troops; he also regards the genus *Formica* as the most brilliant, though some others excel it in other respects, as, for instance, in the sharpness of their senses. *F. pratensis* worries its slain enemies; *F. sanguinea* never does. The slave-making ant (*P. rufescens*) is, perhaps, the bravest of all. If a single individual finds herself surrounded by enemies, she never attempts to fly, as any other ant would, but transfixes her opponents one after another, springing right and left with great agility, till at length she succumbs, overpowered by numbers. *M. scabrinodis* is cowardly and thievish; during wars among the larger species they haunt the battle-fields and devour the dead. *Tetramorium* is said to be very greedy; *Myrmecina* very phlegmatic.

In industry ants are not surpassed even by bees and wasps. They work all day, and in warm weather, if need be, even at night too. I once watched an ant from six in the morning, and she worked without intermission till a quarter to ten at night. I had put her to a saucer containing larvæ, and in this time she carried off no less than a hundred and eighty-seven to the nest. I once had another ant, which I employed in my experiments, under observation several days. When I came up to London in the morning, and went to bed at night, I used to put her in a small bottle, but the moment she was let out she began to work again. On one occasion I was away from home for a week. On my return I let her out of the bottle, placing her on a little heap of larvæ about three feet from the nest. Under these circumstances I certainly did not expect her to return. However, though she had thus been six days in confinement, the brave little creature immediately picked up a larva, carried it off to the nest, and after half an hour's rest returned for another.

We have had hitherto very little information as to the length of life in ants. So far, indeed, as the preparatory stages are concerned, there is little difficulty in approximately ascertaining the facts—namely, that while they take only a few weeks in summer, in some

species, as our small yellow meadow ants, the autumn larvæ remain with comparatively little change throughout the winter. It is much more difficult to ascertain the length of life of the perfect insect, on account of their gregarious habits, and the difficulty of recognizing individual ants. It has, however, generally been supposed that they live about a season, and this is probably the case; but I have still some workers of *F. cinerea*, which I captured at Castellamare in November, 1875, and some of *F. sanguinea* and *F. fusca* since September in that year. They must now, therefore, be at least a year and a half old. I have also some queens of *F. fusca* which have been with me since December, 1874, and still seem in perfect health. If they lived much longer, and could compare their experiences, ants would, from their immense numbers, even in temperate regions, contend with mankind on no such very unequal terms.

The behavior of ants to one another differs very much according as they are alone or supported by numerous companions. An ant which would run away in the first case, will fight bravely in the second.

It is hardly necessary to say that, as a general rule, each species lives by itself. There are, however, some interesting exceptions. The little *Stenamma Westwoodii* is found exclusively in the nests of the much larger *F. rufa* and the allied *F. pratensis*. We do not know what the relations between the two species are. The *Stenammas*, however, follow the *Formicas* when they change their nest, running about among them and between their legs, tapping them inquisitively with their antennæ, and even sometimes climbing on to their backs, as if for a ride, while the large ants seem to take little notice of them. They almost seem to be the dogs—or rather cats—of the ants. Another small species, *Solenopsis fugax*, which makes its chambers and galleries in the walls of the nests of larger species, is the bitter enemy of its hosts. The latter cannot get at them, because they are too large to enter the galleries. The little *Solenopsis*, therefore, are quite safe, and, as it appears, make incursions into the nurseries of the larger ant, and carry off the larvæ as food. It is as if we had small dwarfs, about eighteen inches to two feet long, harboring in the walls of our houses, and every now and then carrying off some of our children into their horrid dens.

Most ants, indeed, will carry off the larvæ and pupæ of others if they get a chance; and this explains, or at any rate throws some light upon, that most remarkable phenomenon, the existence of slavery among ants. If you place a number of larvæ and pupæ in front of a nest of the horse ant, for instance, they are soon carried off; and those which are not immediately required for food remain alive for some days, though I have never been able to satisfy myself whether they are fed by their captors. Both the horse ant and the slave ant (*F. fusca*) are abundant species, and it must not unfrequently occur that the former, being pressed for food, attack the latter and carry off

some of their larvæ and pupæ. Under these circumstances it occasionally happens that the pupæ come to maturity in the nests of the horse ant, and nests are sometimes, though rarely, found in which with the legitimate owners there are a few *F. fuscas*. With the horse ant this is, however, a very rare and exceptional phenomenon; but with an allied species, *F. sanguinea*, a species which exists in our southern counties and throughout Europe, it has become an established habit. The *F. sanguineas* make periodical expeditions, attack neighboring nests of *F. fusca*, and carry off the pupæ. When the latter come to maturity, they find themselves in a nest consisting partly of *F. sanguineas*, partly of *F. fuscas*—the results of previous expeditions. They adapt themselves to circumstances, assist in the ordinary household duties, and, having no young of their own species, feed and tend those of the *F. sanguinea*. But though the *F. sanguineas* are thus aided by the *F. fuscas*, they have not themselves lost the instinct of working. It seems not improbable that there is some division of functions between the two species, but we have as yet no distinct knowledge on this point, and at any rate the *F. sanguineas* can "do" for themselves, and carry on a nest, if necessary, without slaves.

In another species, however, *Polyergus rufescens*, which is not British, this is not the case. They present a striking lesson of the degrading tendency of slavery, for they have become entirely dependent on their slaves. Even their bodily structure has undergone a change: their mandibles have lost their teeth, and have become mere nippers—deadly weapons, indeed, but useless except in war. They have lost the greater part of their instincts: their art, that is, the power of building; their domestic habits, for they take no care of their own young, all this being done by the slaves; their industry—they take no part in providing the daily supplies; if the colony changes the situation of its nest, the masters are all carried by the slaves to the new one; nay, they have even lost the habit of feeding. Huber placed thirty of them, with some larvæ and pupæ, and a supply of honey, in a box.

"At first," he says, "they appeared to pay some little attention to the larvæ; they carried them here and there, but presently replaced them. More than one-half of the Amazons died of hunger in less than two days. They had not even traced out a dwelling, and the few ants still in existence were languid and without strength. I commiserated their condition, and gave them one of their black companions. This individual, unassisted, established order, formed a chamber in the earth, gathering together the larvæ, extricated several young ants that were ready to quit the condition of pupæ, and preserved the life of the remaining Amazons." [1]

This observation has been fully confirmed by other naturalists. However small the prison, however large the quantity of food, these

[1] Huber, "Natural History of Ants."

stupid creatures will starve in the midst of plenty rather than feed themselves. I have had a nest of this species under observation for a long time, but never saw one of the masters feeding. I have kept isolated specimens for weeks by giving them a slave for an hour or two a day to clean and feed them, and under these circumstances they remained in perfect health, while but for the slaves they would have perished in two or three days. I know no other case in Nature of a species having lost the instinct of feeding.

In *P. rufescens*, the so-called workers, though thus helpless and stupid, are numerous, energetic, and in some respects even brilliant. In another slave-making species, however, *Strongylognathus*, the workers are much less numerous, and so weak that it is an unsolved problem how they contrive to make slaves.

Lastly, in a fourth species, *Anergetes atratulus*, the workers are absent, the males and females living in nests with workers belonging to another ant, *Tetramorium cæspitum*. In these cases the *Tetramoriums*, having no queen, and consequently no young of their own, tend the young of the *Anergetes*. It is, therefore, a case analogous to that of *Polyergus*, but it is one in which slave-owning has almost degenerated into parasitism. It is not, however, a case of true parasitism, because the *Tetramoriums* take great care of the *Anergetes*, and, if the nest is disturbed, carry them off to a place of safety.

M. Forel, in his excellent work on ants, has pointed out that very young ants devote themselves at first to the care of the larvæ and pupæ, and that they take no share in the defense of the nest or other out-of-door work until they are some days old. This seems natural, because at first their skin is comparatively soft; and it would clearly be undesirable to undertake rough work or run into danger until their armor had had time to harden. There are, however, reasons for thinking that the division of labor is carried still further. I do not allude merely to those cases in which there are completely different kinds of workers, but even to the ordinary workers. In *L. flavus*, for instance, it seems probable that the duties of the small workers are somewhat different from those of the large ones, though no such division of labor has yet been detected. In *F. fusca* I made an observation which surprised me very much. In the autumn of 1875 I noticed an ant out feeding alone. The next day the same ant was out by herself, and I could easily recognize her because by some accident she had lost the claws of one of her hind-feet. My attention being roused, I watched the nest for some weeks, and saw this same ant out repeatedly, but no other. This winter I have kept two nests under close observation —that is, I arranged with my daughters and their governess, Miss Wendland, most conscientious observers, that we should look at the nest once every hour throughout the day, and this has been done since the middle of November, with a few exceptions not enough

to affect the conclusion. The former nest contains about two hundred, the second about four hundred individuals; but as they are somewhat torpid, and there are no larvæ to be fed, much food is not required. In each case only two or three individuals came out for food, each about twice a day, though some days they did not come out at all. Thinking that possibly these specimens were unusually voracious, or in some other way abnormal, I imprisoned the foragers belonging to one of the nests. The following day two others came out for food, and continued coming for several days. I then imprisoned them also, when two others came out—showing, I think, that the community requires food, and that it was the functions of certain individuals to obtain it.

One of the most interesting problems about ants is, of course, to determine the amount of their intelligence. In order to test this, it seemed to me that one way would be to ascertain some object which they would clearly desire, and then to interpose some obstacle which a little ingenuity would enable them to overcome. With this object in view, I placed food in a porcelain cup on a slip of glass surrounded by water, but accessible to the ants by a bridge, consisting of a strip of paper two-thirds of an inch long and one-third wide. Having then put a *F. nigra* from one of my nests to this food, she began carrying it off, and by degrees a number of friends came to help her. I then, when about twenty-five ants were so engaged, moved the little paper bridge slightly, so as to leave a chasm just so wide that the ants could not reach across. They came to the edge and tried hard to get over, but it did not occur to them to push the paper bridge, though the distance was only about one-third of an inch, and they might easily have done so. After trying for about a quarter of an hour they gave up the attempt, and returned home. This I repeated several times. Then, thinking that paper was a substance to which they were not accustomed, I tried the same with a bit of straw one inch long and one-eighth of an inch wide. The result was the same. I repeated this twice. Again I placed particles of food close to and directly over the nest, but connected with it only by a passage several feet in length. Under these circumstances it would be obviously a saving of time and labor to drop the food on to the nest, or at any rate to spring down with it, so as to save one journey. But, though I have frequently tried the experiment, my ants never adopted either of these courses. I arranged matters so that the glass on which the food was placed was only raised one-third of an inch above the nest. The ants tried to reach down, and the distance was so small that occasionally, if another ant passed underneath just as one was reaching down, the upper one could step on to its back, and so descend; but this only happened accidentally, and they did not think of throwing the particles down, nor, which surprised me very much, would they jump down themselves.

I then placed a heap of fine mould close to the grass, but just so far that they could still not reach across. It would have been of course quite easy for any ant, by moving a particle of earth for a quarter of an inch, to have made a bridge by which the food might have been reached, but this simple expedient did not occur to them. On the other hand, I then put some provisions in a shallow box with a glass top, and a single hole on one side, and put some specimens of *Lasius niger* to the food. As soon as a stream of ants was at work, busily carrying supplies off to the nest, and when they had got to know the way thoroughly, I poured some fine mould in front of the hole so as to cover it up to a depth of about half an inch. I then took out the ants which were actually in the box. As soon as they had recovered from the shock of this unexpected proceeding on my part, they began to run all around and about the box, looking for some other place of entrance. Finding none, however, they began digging down into the earth just over the hole, carrying off the grains of earth one by one, and depositing them, without any order, all round at a distance of from half an inch to six inches, until they had excavated down to the doorway, when they again began carrying off the food as before. This experiment I repeated on the following days three or four times, always with the same result.

As evidence both of their intelligence and of their affection for their friends, it has been said by various observers that when ants have been accidentally buried they have been very soon dug out and rescued by their companions. Without for a moment doubting the facts as stated, we must remember the habits which ants have of burrowing in loose fresh soil, and especially their practice of digging out fresh galleries when their nests are disturbed. It seemed to me, however, that it would not be difficult to test whether the excavations made by ants under the circumstances were the result of this general habit, or really due to a desire to extricate their friends. With this view I tried (20th of August) the following experiments: I placed some honey near a nest of *Lasius niger* on a glass surrounded with water, and so arranged that in reaching it the ants passed over another glass covered with a layer of sifted earth about one-third of an inch in thickness. I then put some ants to the honey, and by degrees a considerable number collected round it. Then, at 1.30 P. M., I buried an ant from the same nest under the earth, and left her there till 5 P. M., when I uncovered her. She was none the worse, but during the whole time not one of her friends had taken the least notice of her.

Again, September 1st, I arranged some honey in the same way. At 5 P. M. about fifty ants were at the honey, and a considerable number were passing to and fro. I then buried an ant as before, of course taking one from the same nest. At 7 P. M. the number of ants at the honey had nearly doubled. At 10 P. M. they were still

more numerous, and had carried off about two-thirds of the honey. At 7 A. M. the next morning the honey was all gone; two or three ants were still wandering about, but no notice had been taken of the prisoner, whom I then let out. In this case I allowed the honey to be finished, because I thought it might perhaps be alleged that the excitement produced by such a treasure distracted their attention; or even, on the principle of doing the greatest good to the greatest number, that they were intelligently wise in securing a treasure of food before they rescued their comrade, who, though in confinement, was neither in pain nor danger. So far as the above ants, however, are concerned, this cannot be urged. I may add that I repeated the same experiment several times, in some cases with another species, *Myrmica ruginodis*, and always with the same results.

Ants have been much praised on account of their affection for their friends. In this respect, however, they seem to vary greatly. At any rate, any one who has watched them much must have met with very contradictory facts. I have often put ants which were smeared with a sticky substance on the boards attached to my nests, and very rarely indeed did their companions take any notice of or seek to disentangle them.

I then tried the following experiment: A number of the small yellow ants (*L. flavus*) were out feeding on some honey. I took five of them, and also five others of the same species, but from a different nest, chloroformed them, and put them close to the honey, and on the path which the ants took in going to and from the nest, so that these could not but see them. The grass on which the honey was placed was surrounded by a moat of water. This, then, gave me an opportunity of testing both how far they would be disposed to assist a helpless fellow-creature, and what difference they would make between their nest-companions and strangers from a different community. The chloroformed ants were put down at ten in the morning. For more than an hour, though many ants came up and touched them with their antennæ, none of them did more. At length one of the strangers was picked up, carried to the edge of the glass, and quietly thrown, or rather dropped, into the water. Shortly afterward a friend was taken up and treated the same way. By degrees they were all picked up and thrown into the water. One of the strangers was, indeed, taken into the nest, but in about half an hour she was brought out again and thrown into the water like the rest. I repeated this experiment with fifty ants, half friends and half strangers. In each case twenty out of the twenty-five ants were thrown into the water as described. A few were left lying where they were placed, and these also, if we had watched longer, would no doubt have been also treated in the same way. One out of the twenty-five friends, and three out of the twenty-five strangers, were carried into the nest, but they were all brought out

again and thrown away like the rest. Under such circumstances, then, it seems that ants make no difference between friends and strangers.

It may, however, be said in this experiment that, as ants do not recover from chloroform, and these ants were therefore to all intents and purposes dead, we should not expect that much difference would be made between friends and strangers. I therefore tried the same experiment, only, instead of chloroforming the ants, I made them intoxicated. This was a rather more difficult experiment. No ant would voluntarily degrade herself by getting drunk, and it was not easy in all cases to hit off the requisite degree of this compulsory intoxication. In all cases they were made quite drunk, so that they lay helplessly on their backs. The sober ants seemed much puzzled at finding their friends in this helpless and discreditable condition. They took them up and carried them about for a while in a sort of aimless way, as if they did not know what to do with their drunkards, any more than we do. Ultimately, however, the results were as follows: The ants removed twenty-five friends and thirty strangers. Of the friends, twenty were carried into the nest, where no doubt they slept off the effect of the spirit—at least, we saw no more of them—and five were thrown into the water. Of the strangers, on the contrary, twenty-four were thrown into the water; only six were taken into the nest, and four of these were shortly afterward brought out again and thrown away.

The difference in the treatment of friends and strangers was, therefore, most marked.

Dead ants, I may add, are always brought out of the nest, and I have more than once found a little heap on one spot, giving it almost the appearance of a burial-ground.

I have also made some experiments on the power possessed by ants of remembering their friends. It will be recollected that Huber gives a most interesting account of the behavior of some ants, which, after being separated for four months, when brought together again, immediately recognized one another, and "fell to mutual caresses with their antennæ." Forel, however, regards these movements as having indicated fear and surprise rather than affection, though he also is quite inclined to believe, from his own observation, that ants would recognize one another after a separation of some months. The observation recorded by Huber was made casually; and neither he nor any one else seems to have taken any steps to test it by subsequent experiments. The fact is one, however, of so much interest, that it seemed to me desirable to make further experiments on the subject. On the 4th of August, 1875, therefore, I separated one of my nests of *F. fusca* into two halves, which I kept entirely apart.

I then from time to time put an ant from one of these nests into the other, introducing also a stranger at the same time. The stranger

was driven out, or sometimes even killed. The friend, on the contrary, was never attacked, though I am bound to say that I could see no signs of any general welcome, or that she was taken any particular notice of.

I will not trouble you with all the evidence, but will content myself with one case.

On the 12th November last—that is to say, after the ant had been separated for a year and three months—I put a friend and a stranger into one of the divisions. The friend seemed quite at home. One of the ants at once seized the stranger by an antenna, and began dragging her about. At—

11.45.—The friend is quite at home with the rest. The stranger is being dragged about.

12.—The friend is all right. Three ants now have hold of the stranger by her legs and an antenna.

12.15.—Do. do.

12.30.—Do. do.

12.45.—Do. do.

1.—Do. do.

1.30.—Do. One now took hold of the friend, but soon seemed to find out her mistake and let go again.

1.45.—The friend is all right. The stranger is being attacked. The friend also has been almost cleaned; while on the stranger the color has been scarcely touched.

2.15.—Two ants are licking the friend, while another pair are holding the stranger by her legs.

2.30.—The friend is now almost clean, so that I could only just perceive any color. The stranger, on the contrary, is almost as much colored as ever. She is now near the door, and I think would have come out, but two ants met her and seized her.

3.—Two ants are attacking the stranger. The friend was no longer distinguishable from the rest.

3.30.—Do.

4.—Do.

5.—Do.

6.—The stranger now escaped from the nest, and I put her back among her own friends.

The difference of behavior to these two ants was most marked. The friend was gradually licked clean, and, except for a few moments, and that evidently by mistake, was never attacked. The stranger, on the contrary, was not cleaned, was at once seized, was dragged about for hours with only a few minutes' interval, by one, two, or three assailants, and at length made her escape from the nest at a time when no other ant was out.

In most species of ants the power of smell is very keen. I placed ants on a strip of paper, each end of which was supported on a pin,

the foot of which was immersed in water. They then ran backward and forward along the paper, trying to escape. If a camel's-hair pencil be suspended just over the paper, they pass under it without taking any notice of it; but if it be scented, say with lavender-water, they at once stop when they come near it, showing in the most unmistakable manner that they perceive the odor. This sense appears to reside, though not perhaps exclusively, in the antennæ. I tethered, for instance, a large specimen of *Formica ligniperda* with a fine thread to a board, and when she was quite quiet I approached a scented camel's-hair pencil slowly to the tip of the antenna, which was at once withdrawn, though the antenna took no notice of a similar pencil, if not scented.

On the other hand, as regards their sense of hearing, the case is very different. Approaching an ant which was standing quietly, I have over and over again made the loudest and most shrill noises I could, using a penny pipe, a dog-whistle, a violin, as well as the most piercing and startling sounds I could produce with my own voice, without effect. At the same time I by no means would infer from this that they are really deaf, though it certainly seems that their range of hearing is very different from ours. We know that certain allied insects produce a noise by rubbing one of their abdominal rings against another. Landois is of opinion that ants also make sounds in the same way, though these sounds are inaudible to us. Our range is, however, after all, very limited, and the universe is probably full of music which we cannot perceive. There are, moreover, in the antennæ of ants certain curious organs which may perhaps be of an auditory character. There are from ten to a dozen in the terminal segment of *Lasius flavus*, the small meadow ant, and, indeed, in most of the species which I have examined, and one or two in each of the short intermediate segments. These organs consist of three parts: a small, spherical cup opening to the outside, a long, narrow tube, and a hollow body shaped like an elongated clock-weight. They may serve to increase the resonance of sounds, acting, in fact, to use the words of Prof. Tyndall, who was good enough to look at them with me, like microscopic stethoscopes.

The organs of vision are in most ants very complex and conspicuous. There are generally three eyes arranged in a triangle on the top of their heads, and on each side a large compound eye containing sometimes more than two thousand facets between them. Nevertheless, the sight of ants does not seem to be very good. In order to test how far ants are guided by vision, I made the following experiments: I placed a common lead-pencil on a board, fastening it upright, so as to serve as a landmark. At the base I then placed a glass containing food, and then put a *L. niger* to the food; when she knew her way from the glass to the nest and back again perfectly well, she went quite straight backward and forward. I then took an oppor-

tunity when the ant was on the glass, and moved the glass with the ant on it about three inches. Now, under such circumstances, if she had been much guided by sight, she could not of course have had any difficulty in finding her way to the nest. As a matter of fact, however, she was entirely at sea, and, after wandering about for some time, got back to the nest by another and very round-about route. I then again varied the experiment as follows: I placed the food in a small china cup on the top of the pencil, which thus formed a column seven and a half inches high. When the ant once knew her way, she went very straight to and from the nest. This puzzled her very much; she went over and over the spot where the pencil had previously stood, retraced her steps several times almost to the nest, and then returned along the old line, showing great perseverance, if not much power of vision. I then moved the pencil six inches. She found the pencil at last, but only after many meanderings.

I then repeated the observation on three other ants, with the same result; the second was seven minutes before she found the pencil, and at last seemed to do so accidentally; the third actually wandered about for no less than half an hour, returning up the paper bridge several times.

Let us compare this relatively to man. An ant measuring say one-sixth of an inch, the pencil, being seven inches high, is consequently forty-two times as long as the ant. It bears, therefore, somewhat the same relation to the ant as a column two hundred and fifty feet high does to a man. The pencil having been moved six inches, it is as if a man in a country he knew well would be puzzled at being moved a few hundred feet, or, if put down in a square containing less than an acre, could not find a column two hundred and fifty feet high, that is to say, higher than the Duke of York's column.

Another evidence of this consists in the fact that if, when my *L. nigers* were carrying off food placed in a cup on a piece of board, I turned the board round so that the side which had been turned toward the nest was away from it, and *vice versa*, the ants always returned over the same track on the board, and consequently directly away from home. If I moved the board to the other side of my artificial nest, the result was the same. Evidently they followed the road, not the direction.

It is remarkable that we do not even now know exactly how an ants' nest is begun. Whether they always commence as a colony from some older establishment; whether wandering workers who chance to find a queen under certain circumstances remain with her and begin a new nest; or whether the queen ant, like the queen wasp, forms a cell for herself, and then brings up a few workers, who afterward take upon themselves the labors of the family, as yet we know not. When once started, the communities last for years, being kept up by a succession of individuals. The queens themselves

rarely or never quit the nest, but receive their food from the workers, and indeed appear to do nothing except lay eggs.

A nest of ants must not be confused with an ant-hill in the ordinary sense. Very often, indeed, a nest has only one dwelling, and in most species seldom more than three or four. Some, however, form numerous colonies. M. Forel even found a case in which one nest of *F. exsecta* had no less than two hundred colonies, and occupied a circular space with a radius of nearly two hundred yards. Within this area they had exterminated all the other ants, except a few nests of *Tapinoma erraticum*, which survived, thanks to their great agility. In these cases the number of ants thus associated together must have been enormous. Even in single nests Forel estimates the numbers at from 5,000 to 500,000.

In their modes of fighting, different species of ants have their several peculiarities. Some, also, are much less military than others. *Myrmecina Latreillii*, for instance, never attack, and scarcely even defend themselves. Their skin is very hard, and they roll themselves into a ball, not defending themselves even if their nest is invaded; to prevent which, however, they make the entrances small, and often station at each a worker, who uses her head to stop the way. The smell of this species is also, perhaps, a protection. *Tetramorium cæspitum* has the habit of feigning death. This species, however, does not roll itself up, but merely applies its legs and antennæ closely to the body.

Formica rufa, the common horse ant, attacks in serried masses, seldom sending out detachments, while single ants scarcely ever make individual attacks. They rarely pursue a flying foe, but give no quarter, killing as many enemies as possible, and never hesitating, with this object, to sacrifice themselves for the common good.

Formica sanguinea, on the contrary, at least in their slave-making expeditions, attempt rather to terrify than to kill. Indeed, when they are invading a nest, they do not attack the flying inhabitants unless they are attempting to carry off pupæ, in which case they are forced to abandon the pupæ. When fighting, they attempt to crush their enemies with their mandibles.

Formica exsecta is a delicate but very active species. They, also, advance in serried masses, but in close quarters they bite right and left, dancing about to avoid being bitten themselves. When fighting with larger species they spring on to their backs, and then seize them by the neck or by an antenna. They also have the instinct of combining in small parties, three or four seizing an enemy at once, and then pulling different ways, so that she, on her part, cannot get at any one of her foes. One of them then jumps on her back and cuts, or rather saws, off her head. In battles between this ant and the much larger *F. pratensis*, many of the latter may be seen, each with a little *F. exsecta* on her back, sawing off her head from behind.

One might, at first sight, be disposed to consider that the ants with stings must have a great advantage over those with none. In some cases, however, the poison is so strong that it is sufficient for it to touch the foes to place them *hors de combat*, or at least to render them incapacitated, with every appearance of extreme pain. Such species have the abdomen unusually mobile.

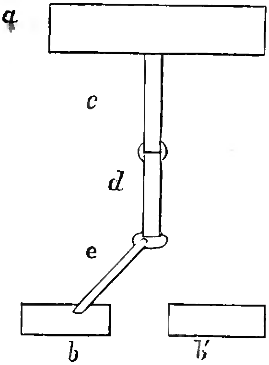
The species of *Lasius* make up in numbers what they want in strength. Several of them seize an enemy at once, one by each of her legs or antennæ, and, when they have once taken hold, they will suffer themselves to be cut in pieces rather than let go.

Polyergus rufescens, the celebrated slave-making or Amazon ant, has a mode of combat almost peculiar to herself. The jaws are very powerful and pointed. If attacked — if, for instance, another ant seizes her by a leg—she at once takes her enemy's head into her jaws, which generally makes her quit her hold. If she does not, the *Polyergus* closes her mandibles, so that the points pierce the brain of her enemy, paralyzing the nervous system. The victim falls in convulsions, setting free her terrible foe. In this manner a comparatively small force of *Polyergus* will fearlessly attack much larger armies of other species, and suffer themselves scarcely any loss.

Much of what has been said as to the powers of communication possessed by bees and ants depends on the fact that, if one of them in the course of her rambles has discovered a supply of food, a number of others soon find their way to the store. This, however, does not necessarily imply any power of describing localities. If the bees or ants merely follow their more fortunate companion, or if they hunt her by scent, the matter is comparatively simple; if, on the contrary, the others have the route described to them, the case becomes very different. To determine this, therefore, I have made a great number of experiments, of which, however, I will here only mention a few. Under ordinary circumstances, if an ant discovers a stock of food, she carries as much as possible away to the nest, and then returns for more, accompanied generally by several friends. On their return, these bring others, and, in this way, a string of ants is soon established. Unless, therefore, various precautions are taken—and this, so far as I know, has never been done in any of the previous observations—the experiment really tells very little.

I therefore made the following arrangement: One of my nests of the small brown garden ant, *Lasius niger*, was connected with a board, on which I was in the habit of placing a supply of food and water. At a short distance from the board I placed two glasses (*b b′*), and on *b* I placed some food. I then connected the glass *b* with the board *a* by three slips of paper, *c*, *d*, *e*, and put an ant to the food. She carried off a supply to the nest, returning for more, and so on. Several friends came with her, and I imprisoned them till the experiment was over. When she had passed several times over the

paper bridges, I proceeded as follows: Any friends who came with her were excluded from the bridges when she was on them. If she was not there, as soon as a friend arrived at the bridge *e*, I took up *e* in my fingers and rubbed it lightly, with a view of removing or blurring the scent; and as soon as the ant arrived on *d* I took up the bridge *c*, and put it across the chasm from *d* to *b'*. Now, if the ant went by description, she would of course cross *e* to *b*. If, on the



other hand, she went by scent, then she would be at the least as likely to go over *c* to *b'*. The results were that, out of about one hundred and twenty friends who passed over *d*, only twenty went to the food, while nearly one hundred passed over *c* to the empty glass. In this case the friends generally came more or less in sight of one another to the bridge *c*, and, once there, could hardly avoid arriving either at *b* or *b'*. I therefore modified the experiment as follows: I established and endowed an ant as before, imprisoning the friends who came with her. When she got to know her way thoroughly, I allowed her to return to the nest on her own legs, but as soon as she emerged again I took her up and transferred her to the food.

Under these circumstances, as will be seen, very few ants indeed ever found their way to the food. I began this at 5.30, when she returned to the nest. At 5.34 she came out with no less than ten friends, and was then transferred to the food. The others wandered about a little, but by degrees returned to the nest, not one of them finding her way to the food. The first ant took some food, returned, and again came out of the nest at 5.39 with eight friends, when exactly the same happened. She again came out—

At 5.44 with 4 friends.	At 6.44 with 0 friends.
" 5.47 " 4 "	" 6.46 " 3 "
" 5.49 " 1 "	" 6.49 " 2 "
" 5.52	" 6.56
" 5.54 " 5 "	" 6.59
" 5.58 " 2 "	" 7.2 " 2 "
" 5.59 " 2 "	" 7.4
" 6.1 " 5 "	" 7.6 " 3 "
" 6.4 " 1 "	" 7.8 " 3 "
" 6.7	" 7.10 " 5 "
" 6.11 " 3 "	" 7.13
" 6.14 " 4 "	" 7.17 " 3 "
" 6.17 " 6 "	" 7.19 " 7 "
" 6.20	" 7.21 " 5 "
" 6.23 " 5 "	" 7.24
" 6.25 " 6 "	" 7.26 " 3 "
" 6.29 " 8 "	" 7.29 " 1 "
" 6.32 " 2 "	" 7.31 " 2 "
" 6.35	" 7.35
" 6.42 " 4 "	

(39 journeys: 11 alone, 28 with 120 friends.)

Thus, during these two hours, more than one hundred and twenty ants came out of the nest, in company with the one under observation. She knew her way perfectly, and it is clear that, if she had been left alone, all these ants would have accompanied her to the store of food. Three of them were accidentally allowed to do so, but of the remainder only five found their way to the food; all the others, after wandering about awhile, returned empty-handed to the nest.

I conclude, then, that when large numbers of ants come to food they follow one another, being also to a certain extent guided by scent. The fact, therefore, does not imply any considerable power of intercommunication. There are, moreover, some circumstances which seem to point in an opposite direction. For instance, I have already mentioned that if a colony of *Polyergus* changes the situation of its nest, the masters are all carried to the new one by the slaves. Again, if a number of *F. fusca* are put in a box, and in one corner a dark place of retreat is provided for them with some earth, one soon finds her way to it. She then comes out again, and, going up to one of the others, takes her by the jaws. The second ant then rolls herself into a heap, and is carried off to the place of shelter. They then both repeat the same manœuvre with other ants, and so on until all their companions are collected together. Now, it seems to me difficult to imagine that so slow a course would be adopted if they possessed any power of communicating description.

On the other hand, they certainly can, I think, transmit simpler

ideas. In support of this I may adduce the following experiment: Two strips of paper were attached to the board just mentioned (p. 54), and parallel to one another, and at the other end of each I placed a piece of glass. In the glass at the end of one tape I placed a considerable number (three to six hundred) of larvæ. In the second I put two or three larvæ only. I then took two ants, and placed one of them to the glass with many larvæ, the other to that with two or three. Each of them took a larva and carried it to the nest, returning for another, and so on. After each journey I put another larva in the glass with only two or three larvæ, to replace that which had been removed. Now, if other ants came under the above circumstances as a mere matter of accident, or accompanying one another by chance, or if they simply saw the larvæ which were being brought, and consequently concluded that they might themselves also find larvæ in the same place, then the numbers going to the two glasses ought to be approximately equal. In each case the number of journeys made by the ants would be nearly the same; consequently, if it were a matter of smell, the two routes would be in the same condition. It would be impossible for an ant, seeing another in the act of bringing a larva, to judge for itself whether there were few or many larvæ left behind. On the other hand, if the strangers were brought, then it would be curious to see whether more were brought to the glass with many larvæ than to that which only contained two or three. I should also mention that every stranger was imprisoned until the end of the experiment. I will select a few of the results:

Experiment 1.—Time occupied, one hour. The ant with few larvæ made six visits, and brought no friends. The one with many larvæ made seven, and brought eleven friends.

Experiment 3.—Time occupied, three hours. The ant with few larvæ made twenty-four journeys, and brought five friends. The one with many larvæ made thirty-eight journeys, and brought twenty-two friends.

Experiment 5.—Time occupied, one hour. The ant with few larvæ made ten journeys, and brought three friends. The other made five journeys, and brought sixteen friends.

Experiment 9.—Time occupied, one hour. The ant with few larvæ made eleven journeys, and brought one friend. The one with many larvæ made fifteen journeys, and brought thirteen friends.

Experiment 10.—I now reversed the glasses, the same two ants being under observation; but the ant which in the previous observation had few larvæ to carry off now consequently had many, and *vice versa*. Time occupied, two hours. The ant with few larvæ made twenty-one journeys, and brought one friend. The one with many larvæ made twenty-two journeys, and brought twenty friends. These two experiments are, I think, especially striking.

Taken as a whole, I found that in about fifty hours the ants which

had access to many larvæ brought two hundred and fifty-seven friends, while those visiting a glass with few larvæ only brought eighty-two. The result will appear still more striking if we remember that a certain number, say perhaps twenty-five, would have come to the larvæ anyhow, which would make the numbers two hundred and thirty-two as against fifty-seven, a very striking difference.

I have elsewhere discussed the relations of flowers to insects, and especially with bees, and particularly the mode in which the flowers were modified so that the bees might transfer the pollen from one flower to another. Ants are also of considerable importance to plants, especially in keeping down the number of insects which feed on them. So far as I know, however, there are no plants which are specially modified in order to be fertilized by ants; and, indeed, even to those small flowers which any little insect might fertilize, the visits of winged insects are much more advantageous, because, as Mr. Darwin has shown in his excellent work on cross and self fertilization of plants, it is important that the pollen should be brought, not only from a different flower, but also from a different plant, while creeping insects, such as ants, would naturally pass from flower to flower of the same plant.

Under these circumstances it is important to plants that ants should not obtain access to the flowers, for they would otherwise rob them of their honey without conferring on them any compensating advantage. Accordingly, we not only find in flowers various modes of attracting bees, but also of excluding ants; and in this way ants have exercised more influence on the vegetable kingdom than might be supposed. Sometimes, for instance, the flowers are protected by *chevaux-de-frise* of spines and fine hairs pointing downward (*Carlina*, *Lamium*); some have a number of glands secreting a glutinous substance, over which the ants cannot pass (*Linnæa*, gooseberry); in others the tube of the flower is itself very narrow, or is almost closed either by hairs or by internal ridges, which just leave space for the proboscis of a bee, but no more. Lastly, some, and especially pendulous flowers (*Cyclamen*, snowdrop), are so smooth and slippery that ants cannot easily enter them, but often slip off in the attempt, and thus are excluded, just as the pendulous nests of the weaver-birds preclude the entrance of snakes. This, however, is a large subject, into which I cannot now enter.

Let me, in conclusion, once more say that, as it seems to me, notwithstanding the labors of those great naturalists to whom I gratefully referred in commencing, there are in natural history few more promising or extensive fields for research than the habits of ants.—*Fortnightly Review.*

THE NEW STAR IN THE CONSTELLATION OF THE SWAN.[1]

BY AMÉDÉE GUILLEMIN.

THE phenomenon of a new star appearing in the heavens is sufficiently rare to strike the imagination of the public, as well as to attract the attention of scientific men. On the one side, it possesses all the interest which attaches to the unexpected, to the mysterious unknown; and, on the other, it raises some very important questions as to the physical and chemical constitution of the stars, and as to the likeness between those distant suns and our own. But now more than ever before, more even than in the first moiety of the nineteenth century, is such curiosity justified, inasmuch as the new means of investigation in the hands of astronomers give promise of revealing, at least in a great measure, the nature of the strange transformations which give rise to these apparitions.

Before we consider the quite recent discovery made by Julius Schmidt, director of the observatory at Athens, let us make a brief review of the apparitions which preceded it.

Every one has seen in works on astronomy the account of the famous temporary star of 1572, which appeared during the month of November in the constellation of Cassiopeia, all of whose phases were observed by Tycho Brahe. Its extraordinary scintillation; its brightness, equaling and surpassing Vega, Jupiter, Sirius, and even Venus when in quadrature, so that it was visible at high noon; finally, its sudden diminution and disappearance after seventeen months of visibility, all conspired to give to this star an extraordinary celebrity.

In 1600 a new star appeared in the Swan, and was studied by Kepler; then it disappeared in 1621, was again visible in 1655, and at sundry times afterward; it is still visible.

Thirty years after the disappearance of the new star in Cassiopeia appeared the star in Serpentarius discovered by Brunowski in October, 1604, and which had for its observer and historian the great Kepler. It was visible for eighteen months, and, while it did not equal in brightness the star of 1572, it surpassed the stars of first magnitude, and even Jupiter itself.

In 1670 a third temporary star was discovered by the Carthusian Anthelme, in that part of the constellation of the Fox which is nearest to β of the Swan. At the time of its apparition, or rather of its discovery, June 20th, it was of the third magnitude. About August 10th it was only of the fifth magnitude, and three months later it disappeared, reappearing on March 17, 1671, with the lustre of a star of

[1] Translated from the French by J. Fitzgerald, A. M.

the fourth magnitude. The temporary stars of 1572 and 1604 had directed the attention of astronomers to the variableness of the light of stars; and already, in 1650, Bouillaud had approximately determined the period of Mira Ceti, or the star *o* in the constellation of the Whale. Cassini, who observed sensible variations in the star of the Fox, supposed that its period could be fixed at ten months; but it was sought for in vain in February, 1672; it did not reappear till the end of March, being at that time of the sixth magnitude; then it disappeared once more, and has since never been seen.

Between the star of the Fox and the star discovered on April 28, 1848, by Hind in Ophiuchus (or Serpentarius), 177 years elapsed. The star of 1848, which was of a dark yellow or reddish color, did not exceed the fifth magnitude, but the variations of its light were carefully studied during the whole period of its visibility. In 1850 it was hardly of the eleventh magnitude, and this magnitude it has since kept.

Here we may refer to the researches made since Cassini's time into ancient writings, whether European or Chinese, which show that many similar apparitions of new stars have been noted in chronicles and afterward forgotten: for instance, the star of the year 125 B. C., observed by Hipparchus, as we learn from Pliny; another, which appeared in the Emperor Hadrian's time; the new star seen in the constellation of the Eagle in the year 389, and which possessed a brilliancy resembling that of Venus; that seen in the Scorpion in the ninth century; the new stars of the years 945 and 1264, both of which made their appearance in very nearly the same part of the heavens between Cepheus and Cassiopeia.

Before we come to the two latest temporary stars, which have succeeded each other in an interval of ten and a half years, and which are worthy of a detailed description, let us briefly state the questions to which these apparitions have given rise among astronomers, and the hypotheses which have been offered for their solution.

To what causes must we refer the nearly always sudden apparitions of these strange bodies, their variations of lustre, their intermittence, as also their changes of color? Why is it that, after alternations of great lustre and of paling, their light gradually faded away, and what is the cause of their ultimate disappearance?

A thousand conjectures have been made in the effort to answer this question. Among the weightiest of these, the one which compares temporary stars to variable periodic stars must be rejected at once—not on the ground that these two classes of stars are absolutely distinct, but because the periodicity being due, either to a movement of rotation or to occultation on the one hand, or to a phenomenon peculiar to the star itself on the other, the first hypothesis is clearly inadmissible for the explanation of new stars, and the second is precisely the question to be solved.

Tycho Brahe, struck with the suddenness of the appearance of the star of 1572, and its position on the edge of the Milky-Way, offered a bold hypothesis which is now abandoned. He believed in a creation, or at least in the spontaneous incandescence of the nebulous matter of which he supposed the Milky-Way to be composed: when the new star vanished, the place it had occupied was void, or at least Brahe saw, in the absence of nebulosity at that spot, the result of the condensation of the matter the combustion of which had produced an appearance resembling a star. Humboldt justly compares this view, which at all events was an ingenious one, with the views held by W. Herschel as to the transformation of nebulæ into stellar masses. In Tycho Brahe's time it was not known that the light of the Milky-Way results from the aggregation of an indefinite number of stars, or stellar masses, and that it is within this immense agglomeration and in its vicinity that the nebulæ properly so called are rarest.

Besides, it has been proved that the stars known as "new" stars are anything but new. In the spot where the star of Ophiuchus made its appearance in 1848, there had previously been a star, noted by Lalande in Fortin's "Atlas Céleste" as a vanished star. So, too, the new star which appeared in May, 1866, in the Corona Borealis, and which at the start reached the second magnitude, had been already set down in catalogues as a star of the ninth magnitude; it still possesses the same lustre it had before it underwent, during the six months of its apparition, the extraordinary augmentation which attracts to it the attention of astronomers. Hence astronomers no longer believe in the creation or in the destruction of these stars. Before the sudden incandescence which makes them visible, they occupied the same places, and there they still remain after their more or less perfect extinction. It remains to inquire into the physical causes which produce these variations of lustre.[1]

Spectrum analysis has provided the first positive elements for the solution of this problem. As late as the year 1848 this method was as yet unknown; but when in 1866 the variable star of the Northern Crown (*Corona Borealis*) appeared, spectrum analysis was already so developed as to be profitably applied to the observation of it. The results obtained by Huggins and Miller in these researches were as follows:

[1] It is worth while to observe the ease with which these knotty questions are disposed of by persons who are wont to invoke supernatural agencies. Here is an instance dating from the seventeenth century, but similar instances may be found in our own time: Father Riccioli, as an explanation of the appearance of secondary stars, suggested the idea that some stars are luminous on one side; and whenever God would "exhibit to men some extraordinary sign, he turns toward them the luminous side (previously turned away from the earth) by causing the star to revolve about suddenly, either by the agency of some intelligent being, or in virtue of some faculty inherent in the star itself; then, by making another similar revolution, it suddenly vanishes, or pales gradually, like the moon in its phases." The explanation offered by the learned Jesuit is both ingenious and convenient. But, unfortunately, astronomers nowadays are not satisfied with it.

"The spectrum of the variable star of Corona Borealis is found to consist of two superposed spectra, the one made up of four bright lines, and the other resembling the solar spectrum, each resulting from the decomposition of a group of luminous rays independent of the light which produces the other. The continuous spectrum, furrowed with groups of dark rays, indicates the presence of a photosphere of incandescent matter, almost certainly solid or liquid, and surrounded by an atmosphere of cooler vapors, which produce by absorption the groups of darker lines. So far the constitution of this star resembles that of the sun; but it offers an additional spectrum composed of bright lines. Here, then, is a second source of special light, and this source must *be a luminous gas.* Furthermore, the two principal bright lines of this spectrum show that this gas consisted mainly of hydrogen; and their great brightness proves that the temperature of the luminous gas was higher than that of the photosphere. These facts, taken in connection with the suddenness of the outburst of light in the star, its immediate and rapid diminution of brightness, and its decline, in the course of twelve days, from the second to the eighth magnitude, lead us to the conclusion that the star was suddenly enveloped in hydrogen-flames. Possibly it was the scene of some mighty convulsion, with disengagement of an enormous amount of liberated gas. A great portion of this gas was hydrogen, which burned on the surface of the star by combining with some other element. The light given forth by this flaming gas was characterized by the spectrum with bright lines. The spectrum of the other portion of the star's light probably showed that this terrible conflagration of gas had surcharged and rendered more vividly incandescent the solid matter of the photosphere. When the free hydrogen had been exhausted, the flame died away by degrees, the photosphere became less luminous, and the star returned to its former state. . . . We must not forget," adds Mr. Huggins, "that light, though it travels with such great velocity, nevertheless requires a certain time to come to us from the star. Hence this grand physical convulsion, though new to us, was a thing of the past as regards the star itself. In 1866 the star had already for years been in the new conditions produced by this violent catastrophe."

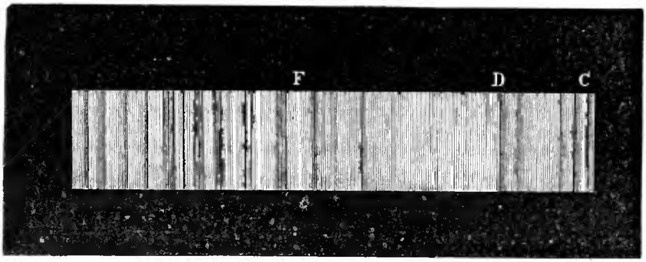


FIG. 1.—SPECTRUM OF THE VARIABLE STAR IN CORONA BOREALIS. (From Huggins and Miller.)

The solar protuberances had not as yet been directly analyzed in 1866; it was not yet known that a continuous stratum of incandescent hydrogen envelops the bright photosphere of the sun, and that the emission of this gas, in the form of irregular jets, undergoes in the sun variations, phases, which are at least so far related to the sunspots as to be coincident with them. What mighty physical revolu-

tion was it that suddenly produced the incandescence of the sun of the Corona, transforming it from a star of the ninth to one of the second magnitude?

What would become of our planet were such a revolution as this to take place in the sun, and were the calorific and luminous radiation to be suddenly increased a hundred-fold?

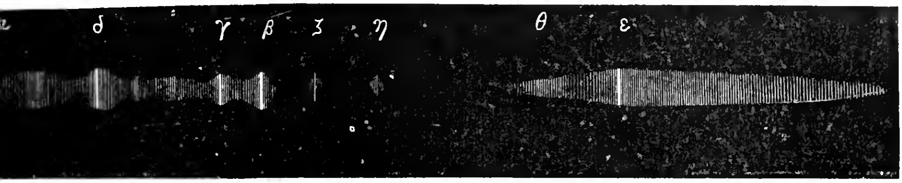


Fig. 2.—Spectrum of the New Star in the Constellation of the Swan. (From Cornu.)

But let us come to the new star of the Swan, which is the main object of this article. Here is a very brief narrative of its discovery.

Julius Schmidt, director of the observatory at Athens, recently wrote to M. Le Verrier the following letter:

"On November 11th, at $5^h\ 40^m$ in the evening, I saw a star of the third magnitude in the zenith, near ρ Cygni. Observations with the refractor of the observatory, at $9^h\ 30^m$, gave the position of the star as follows:

1876. O	Right ascension..........................	$21^h\ 36^m\ 50.4^s$
	North declination..........................	$42°\ 16'\ 30.5''$

"The position for the year 1855 would be:

Right ascension..........................	$21^h\ 36^m\ 1.2^s$
Declination..............................	$42°\ 11'\ 1''$

"It does not occur in the Bonn "Durchmusterung des Himmels." The star is strongly yellow in color. At midnight it was more intense than μ Pegasi (which is set down as of the third magnitude in Heis's catalogue). On November 20th the star was not visible. On the 21st, 22d, and 23d, the sky at Athens was overcast. From November 24th out, it has steadily declined in brightness, and on December 8th the star was a little below the sixth magnitude."

At Paris, too, the sky was almost constantly overcast for some days after the reception of Schmidt's letter. By taking advantage of infrequent and imperfect seasons of clear sky, Prosper Henry succeeded in observing the new star. Compared with the star 915 of Weisse's catalogue (hour 21), it had this approximate position:

1876. O	Right ascension........................	$21^h\ 36^m\ 50^s$
	Declination............................	$+\ 42°\ 16'\ 34''$

It was of the fifth magnitude, and appeared to be of a greenish color, almost blue, as compared with a neighboring star (42,304 of Lalande).

The new star was also observed at Vienna by Littrow. To him

on December 1st, as to Schmidt on November 24th, it appeared to be of from the third to the fourth magnitude; on December 3d it had fallen to the fourth magnitude, and on December 4th to the fifth magnitude. The right ascension was $24^h\ 36^m\ 50.4^s$; declination, $+42°\ 16'\ 37.7''$ for 1886. O.

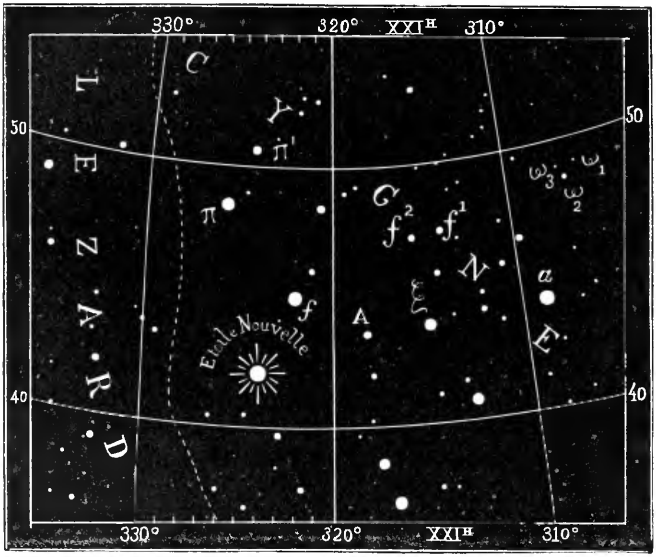


FIG. 3.—MAP SHOWING PORTION OF NEW STAR IN THE SWAN. LÉZARD—THE LIZARD; CYGNE—THE SWAN; ÉTOILE NOUVELLE—THE NEW STAR.

We may observe here that there is nothing in common between this new star and those which made their appearance in 1600 in the neck of the Swan, and in 1670 near β of the same constellation. The only point of agreement between them is their nearness to the Milky-Way.

In comparing Schmidt's observations with those of Prosper Henry, we note two important facts: the first is, the diminution of lustre, varying in eight days from the third to the fifth magnitude; and, second, the notable change of color, from a pronounced yellow to greenish blue—a change so patent that it cannot be referred to individual differences of judgment, or to atmospheric influences.

The new star of the Swan has been made the subject of a very interesting spectroscopical study. As early as December 2d, Cornu applied a spectroscope to the great equatorial in the eastern tower of the Paris Observatory. Cazin, too, employed for the same purpose the nine-inch equatorial telescope (the object-glass of which is by Léon Foucault). Both of these observers arrived at the same conclusion. The spectrum of the star, observed during a brief interval of clear sky, appeared to "consist in great part of bright lines, and hence

probably to be the result of an incandescent vapor or gas." Here, it will be seen, is a first point of resemblance to the variable star of Corona Borealis.

A second study, made by Cornu on December 4th, enabled him to define the bright lines of the spectrum. Three of them are the lines *C*, *F*, and 434 of hydrogen; a fourth line seemed to correspond to the line *D* of sodium; another to the characteristic line *b* of magnesium. Finally, two lines with the wave-lengths 531 and 451 seem to coincide, the one with the famous line 1,474 (Kirchhoff's scale) observed in the solar corona during eclipse, the other with a line of the chromosphere. These results possess so high an interest that we will here transcribe a portion of the text of M. Cornu's note:

"The spectrum of this star," he writes, "consists of a certain number of detached bright lines on a sort of luminous ground, almost entirely interrupted between the green and the indigo, so that the spectrum appears as though made up of a number of separate parts. In order to study it qualitatively, I adopted a spectroscopic eye-piece of special construction, which utilizes most of the light, and allows the observer to vary its concentration. In measuring I used a direct-vision Duboscq spectroscope. I observed only bright lines; the dark lines, if any there are, must be very minute, and escaped my observation, owing to the faintness of the star's light."

In this respect the spectrum of the star in the Swan differs from that of the star *T* of Corona Borealis, as may be seen from the figure here copied from Huggins.

We omit the details of the measurements of the positions of the lines, and pass to the results, which are stated in the following table. The bright lines, ranged in the order of their brightness, α, δ, γ, β, ζ, η, θ, ϵ, are eight in number, and their wave-lengths are here given in millionths of a millimetre:

	α	δ	γ	β	ζ	η	θ	ϵ
Lines observed.......	661	588	531	517	500	483	451	435
Hydrogen	665 (*C*)	....	..	....	..	486 (*F*)	..	434
Sodium	....	589 (*D*)	..	....	..	....	..	..
Magnesium....	....	....	..	517 (*b Mg.*)	..	....	..	..
Corona line....... ...	....	....	532	....	..	....	..	..
Chromosphere line....	....	587	..	....	..	....	447	..

From this table it is seen that there is almost perfect coincidence as regards the lines α, η, and ϵ, with three hydrogen-lines; as regards β, with the line *b* of magnesium; as regards δ, with the line of sodium, or, perhaps, as Cornu suggests, with the bright line D_3 of the chromosphere. The γ corresponds with a bright line also belonging to the chromosphere and the solar corona; and, finally, θ corresponds with a line of the chromosphere. The line ζ alone stands unidentified with any known line.

"If this interpretation were correct, the bright lines of the spectrum of the star would comprise exclusively the brightest and most frequent lines. of the chromosphere."

In the extreme violet there is a line, the fourth of hydrogen, also noted by Dr. Young, as one of the most frequent in the spectrum of the chromosphere, the wave-length of which is 410. Cornu thinks he has often perceived this line in the spectrum of the star, but he has not been able to measure it. The distinguished observer closes his account of these interesting researches as follows:

"To sum up, the light of the star seems to have precisely the same composition as the light of the sun's envelope, the *chromosphere*. Though the temptation is strong to draw from this fact conclusions as to the physical condition of this new star, its temperature, the chemical reactions it must exhibit, I will make no comments, nor offer any hypotheses. We lack, I think, the data necessary for reaching a profitable conclusion, or at least a conclusion that can be verified. However attractive such hypotheses may be, we must not forget that they lie outside of the domain of science, and that, instead of being of service to science, they are likely to hinder its progress."

The readers of *La Nature* will permit us to add a few reflections of our own to those offered by our learned fellow-countryman. His reserve we acknowledge to be very wise, but he has expressed himself a little too strongly. Who, after perusing M. Cornu's analysis and the conclusions he has drawn, would not make the short step that here intervenes between fact and hypothesis, and assert the similarity, if not the identity, of the light of the star with that of the chromosphere? True, we cannot with certainty affirm that the apparently continuous faint spectrum in which are seen the bright lines was also its spectrum before it became visible to us, but that such is the case is highly probable. We cannot say what was the cause of this sudden development of gases, whose existence and incandescence are revealed by the star's spectrum, just as we are as yet unable to assign the cause of the sun's hydrogen protuberances. But is it nothing to class together phenomena, the only difference between which seems to be one of degree alone? The hypotheses of Huggins and Miller, as to the causes of the apparition of the star in the Corona Borealis, can of course never be verified; but no more can we verify the current hypotheses held by astronomers and physicists with regard to the presence of various chemical elements in the sun; we have here only probabilities. Such hypotheses, far from being of injury to science, are indispensable for its progress: they stimulate the observer's mind, constantly suggest to him fresh observations, and become a hinderance only when they are held to be demonstrated truths, and when men refuse to give them up after they have been proved to be erroneous, or after they have served their purpose.—*La Nature*

ANTIQUE MARBLES.

By JOHN D. CHAMPLIN, Jr.

NOTHING more forcibly attests the imperial power and magnificence of Rome, at the height of her glory, than the fragments of precious marbles which almost every excavation among her ruins brings to light. Even if her history were lost to us, these varied bits of stone would tell in language stronger than words the story of her universal dominion, when her ships sought every clime, and every land paid tribute to her luxury. This piece reflects the glowing suns of Numidia, that the green of Tempe's Vale; this was quarried on Pentelicus, this in storied Chios, and these tell of Gallic and of Hispanic conquest. Many have a double history, having served to decorate some forum or temple of the East before its spoliation by a Mummius or a Sulla.

Toward the end of the second century B. C. the Romans, who had become conversant with Greek art through their conquests, began to appreciate sculptures and precious marbles, and from that time onward almost every captured city was rifled of its treasures. Not only were all the quarries of the world put under contribution, but statues, columns, and capitals, slabs, pavements, and sometimes entire edifices, were transported to Rome. Carthage, from the time of its destruction, furnished an almost inexhaustible supply. Edrisi, the Arab geographer of the twelfth century, says that marbles of so many different species were found among its ruins that it would be impossible to describe them. Blocks thirty feet high and sixty-three inches in diameter, and columns thirty feet in circumference, were taken out.

A large fleet of vessels was employed solely in transporting marbles, and slaves or freedmen were stationed in the various ports from which they were sent, who were charged with the duty of keeping account of the number, quality, and date of shipment of all stones. In 1868 excavations on the banks of the Tiber brought to light the ancient *marmorata*, or marble-wharf, where these vessels landed their cargoes. Many blocks of precious colored marbles were exhumed here, some of colossal proportions. One of yellow African marble was twenty-seven feet long by five and a half feet wide, and weighed thirty-four tons. Another, sent from a then newly-opened quarry in the mountains north of the Adriatic, to the Emperor Nero, was marked with the name of his freedman Caryntbus.

So immense was the store of marbles amassed in Rome that for centuries after her spoliation by the northern barbarians her ruined edifices were regarded as the richest of quarries, from which pope, nobles, and peasants, drew at will. Most of the mediæval churches and other public edifices now extant are decorated with the spoils of

imperial palaces, basilicas, baths, and the temples of the gods. Vast quantities of marble were even burned for lime; and, as if in retribution, Rome was robbed to beautify other cities. Her sculptured marbles were transported to Aix-la-Chapelle to decorate the buildings of Charlemagne, and the ancient capital of the world, Petrarch laments, was forced to adorn from her own bowels the slothful luxury of Naples.

Of the white marbles of antiquity the most important were the Parian and the Pentelic, both the product of Greek quarries. The Parian was obtained from Mount Marpessa, in the island of Paros, one of the Cyclades, whence it was sometimes called Marpessian. It was also called *lychnites*, because, says Pliny, the quarries were worked by lamplight. Dodwell disputes this, averring that the quarries are cut down the mountain-side and open to the light; and he suggests that the marble was so called from its glittering fracture, or its translucence. This leads one to doubt whether Dodwell ever visited them, for Bory Saint-Vincent, of the French commission to the Morea, expressly describes them as subterranean, and says the entrance of the principal one was so filled up at the time of his visit that he was obliged to creep to enter it. There are three quarries on the mountain, and the largest has several lateral cuttings. The marks of the ancient wedges are everywhere visible, and it is evident from the manner in which the blocks were taken out that the utmost care was exercised to avoid waste. In consequence of the numerous fissures through the beds, comparatively small blocks could be obtained, generally not more than five feet in length.

Parian marble is of a yellowish white, very near the tint of white wax. Theocritus compares it to the color of teeth. It was, therefore, considered better adapted for the representation of human flesh than any other material. Its grain is much coarser than that of the Pentelic marble, but it takes a most exquisite polish, and, as it gradually hardens by exposure to atmospheric air, it resists decomposition for ages. To this quality is attributable the fine state of preservation of many of the most celebrated of the antique statues, such as the "Venus de' Medici," the "Diana Venatrix," the "Juno Capitolina," the "Ariadne," and the colossal "Minerva"—otherwise called the "Pallas of Velletri"—all of which are of Parian marble.

The neighboring island of Naxos produced a white marble scarcely inferior to that of Paros, but exhibiting a little more advanced state of crystallization. The marble, too, of Tenos, an island north of Paros, and of Thasos, the most northerly of the Ægean group, was considered nearly equal to that of Paros. Chios, Lesbos, Samos, and several other islands of the archipelago, also produced white marbles, generally of a more snowy white than the Parian. They are called usually by the Italians *marmo Greco.*

In the palmy days of Greek art the Athenians gave the preference

to the Pentelic marble, rather than to that of Paros, probably because it was more accessible to Athens, the quarries being on Mount Pentelicus, only about eight miles from the city. It is finer in grain than the Parian, and is whiter, but it is less translucid, and it has a tendency to exfoliate under atmospheric influence, so that it loses in time its polished surface. It is marked, too, by occasional zones of greenish talc, whence it is called by the Italian sculptors *cipolino statuario*, from its resemblance to an onion (*cipola*). It is sometimes called also *marmo salino*, from its salt-like grains. The Parthenon, the Propylæa, the Erechtheum, and most of the other principal buildings of Athens, were constructed of Pentelic marble, and it was also the material of some of the most celebrated of the ancient statues, such as the "Venus" of the Capitol, the "Pallas" of the Albani villa, the "Indian Bacchus," and many portrait busts.

The Pentelic quarries, says Dodwell, are cut in perpendicular precipices in the side of the mountain. The marks of the tools are everywhere visible, and the tracks of the sledges on which the immense masses were drawn down the declivity to the plain are still to be seen. Several frusta of columns and other blocks lie at the base of the excavation, just as they were left by the ancient quarrymen. One of the larger excavations is worked now.

The Hymettan marble, from Mount Hymettus on the southeast side of Athens, was employed in Xenophon's time in the construction of temples, altars, shrines, and statues, throughout Greece, but especially in Athens. The Romans used it to a much greater extent than the Pentelic, partly because the quarries were nearer the sea, and partly because its peculiar tint became the fashion. It was of a much less brilliant white than the Pentelic, in some places becoming almost gray. It was used chiefly for buildings. According to Pliny, Lucius Scaurus was the first in Rome to decorate his house with Hymettan columns, 104 B. C. The statue of Meleager, in Paris, is made of this marble.

In the time of Julius Cæsar quarries of white marble were opened at Luna, on the coast of Etruria, and thenceforth Rome drew her supply of building-marbles from this place, almost to the exclusion of the Greek marbles. The Pantheon, and many other public buildings, were constructed of it. It was soon found to be adapted also for statuary, and finally came to be preferred to the Parian. The "Antinous" of the Capitol, now in the Paris Museum, is of this marble, and, according to some, the "Apollo Belvedere" also; but the Roman sculptors think the latter is a Greek marble. The marble of Luna, called by the ancients *marmor Lunense*, and which is the same as the modern Carrara, is whiter than either the Parian or Pentelic, and some of its veins are not inferior in beauty of grain and in softness to the former.

In 1847 a quarry of white marble was opened at Maremma, about

thirty-five miles from Leghorn, which bore many evidences of having been worked in ancient times. It closely resembles the Parian in color and grain, works smoothly, and takes a high polish.

White marbles were also obtained by the ancients from Mount Phelleus, Rhamnus, and Sunium, in Attica; Demetrias, in Thessaly; on the river Sangarius, in Phrygia; from near Alexandria Troas; from Mount Prion, near Ephesus; from Cappadocia, and from Mount Libanus, the modern Lebanon.

The marbles of Phelleus, Rhamnus, and Sunium, were of good color, but were coarse, and less homogeneous than the Pentelic. The Sangarian marble was sometimes called Coralitic. The Cappadocian was called Phengites (Φέγγος), on account of its translucence. The temple of Fortuna Seia, built by Nero within the precincts of his Golden House, was built of this stone; and, although it had no windows, it is said to have been perfectly light when the door was closed. The marble of Mount Libanus, usually called Tyrian, was probably the material of Solomon's Temple and of Herod's palace. The *Scala Santa* in the Lateran Palace, Rome, said to have been brought from Pilate's house in Jerusalem, is of this marble, which is a clear blue-white.

The Proconnesian marble, a pure white with black veins, was quarried in the island of Proconnesus, in the Propontis. The celebrity of this stone has changed the name of the island to Marmora, and also given its modern name (Sea of Marmora) to the Propontis. This marble was also called Cyzican, because it was largely used in the city of Cyzicus, opposite the island in Mysia. The palace of Mausolus, at Halicarnassus, was built of it. It was also much used at Constantinople, under Honorius and the younger Theodosius. Several columns of it in the mosque of St. Sophia were spoils of the temple of Cybele at Cyzicus.

A white marble, with yellow spots, was brought from Cappadocia, and a similar marble from Rhodes, but the spots were of a brighter, more golden, yellow. White marble, with black spots, was quarried in the Troad.

But the most beautiful of the antique variegated marbles, with a white base, was the Synnadic, Docimæan, or Docimite, sometimes called *marmor Phrygium*. It was quarried at the village of Docimia, not far from Synnada, in Phrygia Major. The ancient authorities generally describe it as pure white, marked with red or purple veins, which the poets compared to the blood of Atys, slain at Synnada; but Hamilton, who visited the quarries about 1835, says that they yield several different kinds. He mentions white, bluish-white, white with yellow veins, white with blue veins, and white with blue spots, the latter having almost a brecciated appearance. He describes the principal quarry as worked horizontally into the hill, the sides of which are cut away perpendicularly to a great height to secure the splendid columns for which it was famous. Strabo says that pillars

and slabs of surprising magnitude and beauty, approaching the alabastrite marble in variety of colors, were conveyed thence to Rome, notwithstanding the long land-carriage of more than 100 miles to the place of shipment. The quarries are entirely surrounded by trachytic hills, to which, says Hamilton, the marble "owes its crystalline and altered character, being to all appearance a portion of the older secondary limestone caught up and developed by the protruded volcanic rocks, and crystallized by igneous action."

The alabastrites marble of the ancients, or onychites, was not a marble proper, but a hard carbonate of lime, identical in composition with stalagmite, the modern alabaster. It was quarried, says Pliny, near Thebes, in Egypt, and Damascus. When first brought to Rome it was considered almost a precious stone, and was made into cups and small ornaments, such as the feet of couches and chairs. When Balbus decorated his theatre, in the time of Augustus, with four small columns of this stone, it was noted as an unprecedented occurrence; but, in the reign of Claudius, Callistus, a freedman of that emperor, adorned his banquet hall with thirty large columns of alabastrites. The ancient quarries were reopened by Mehemet Ali, Viceroy of Egypt, to obtain material to build his mausoleum at Cairo. The four magnificent pillars of this marble that support the baldacchino over the altar in the church of San Paolo fuori le Mura, in Rome, were presented by him. Each is a monolith forty feet long.

Of the yellow marbles of antiquity, that called by the Italians *giallo antico* is the rarest and most beautiful. There are several varieties of it, varying in tint from a cream-yellow to the deepest chrome-yellow, sometimes shading into red and purple hues. Some is as bright as gold (*giallo dorato*), some of an orange-shade (*giallo capo*), and some, extremely rare, of a canary-color (*giallo paglia*). The ancient writers compared it to saffron, to sunlight, and to ivory grown yellow with age. Some of it is variegated with black or dark-yellow rings. The grain is exceedingly fine. Its colors are derived entirely from carbonaceous matter. Among the finest existing specimens of this marble are the large columns in the Pantheon at Rome, and a single pair in the Arch of Constantine. The *giallo antico* was called *marmor Numidicum* by the Romans, but the precise site of the quarries is not yet ascertained. M. Fournel believes that the yellow marble of Philippeville, Algeria, which closely resembles it in varying tints, is identical with it. The island of Melos and Corinth also produced yellow marbles, and in the time of Justinian a marble of a fiery yellow was quarried in the neighborhood of Jerusalem.

Among the most celebrated marbles of the ancient world was the *rosso antico*, or red antique. Its color passes from a red, almost scarlet, to a wine-lees or blood-red, which is divided by parallel layers of white, and sometimes also intersected by a network of delicate black veins. Its variation in tint is probably according to the quan-

tity of the oxide of iron contained in it. Until lately this marble was known only through its remains, and it has generally been ascribed to Egypt. The largest ancient specimens preserved are the fourteen slabs composing the double flight of steps in the church of San Prassede, Rome. Napoleon I. at one time intended to carry these to Paris to ornament his throne. There are several statues of *rosso antico*, including the "Antinous" in Paris and the "Marcus Agrippa" in the Grimani Palace, Venice, and many medallion portraits. It is now ascertained that this beautiful marble was not Egyptian, but Greek. It was quarried on the coast of the gulf of Laconia, near what is now the bay of Scutari. The quarry lies near the sea, and large blocks cut by the ancients are still to be seen there. In 1851 the Greek Government sent specimens from it to the London Exposition, and it was fully recognized as the famous *rosso antico*.

There are many varieties of the marble called red and white antique, but they are so near alike that it is impossible to distinguish them by description alone. They are variously called by the Italians *rosso annulato*, *serpentelo*, *vendurino*, *fiorito*, *cotonello*, etc. They are found only in the Roman ruins, and their quarries are unknown. The marble called *cervelas* is of a deep red, with numerous gray and white veins. It is supposed to have been brought from Africa.

The ancients were acquainted with many kinds of green marble, one of the most noted of which was the *marmor Atracium*, called by Julius Pollux Thessalian, and identical with the *verde antico* of the Italians. The quarries were on Mount Ossa, near the entrance of the vale of Tempe, and not far from Atrax in Thessaly, whence it derived its name. It is a species of breccia, whose paste is a mixture of talc and limestone, interspersed with fragments of white marble. But the verde antique marbles differ from the modern breccias in that the colors are so blended that the line of demarkation is not perceptible. The Erechtheum in Athens was adorned with columns of verde antique, and it was one of the marbles selected by Justinian for the decoration of St. Sophia. The eight splendid columns of it still to be seen in the mosque are said to have been taken from the temple of Diana at Ephesus.

The celebrated Carystian marble, the *cipolino verde* of the Italians, derived its name from Carystus, a town at the foot of Mount Oche, in the island of Eubœa, where it was quarried. The temple of Apollo Marmarinus of Carystus was named from this quarry. It is a true steatitic limestone or cipolin, and is of a beautiful grayish green, with white zones and spots, and sometimes sprinkled with different colors. It was easily obtained in very large blocks, suitable for columns, and was largely used in the temples and other public buildings in Athens and Rome. An English traveler, who visited the quarry lately, found seven entire columns on the site, about three miles from the sea, just as they were left by the ancient workmen.

The *marmor Lacedæmonium*, *Laconicum*, or *Spartum*, of the Romans has always been regarded as a species of verde-antique marble. Clarke says that it differed from the Atracian only in being variegated with black or dark-green serpentine instead of with white. But M. Boblaye, the mineralogist of the French commission to the Morea, has proved pretty conclusively that it was not a marble but a true porphyry, and probably identical with the *ophites* of the ancients, which Pliny says was so called from its resemblance to the skin of a serpent (ὀφις). Pausanias calls it Croceean stone (*Κρόκεων λίθος*). The French discovered the quarries near the ancient Croceæ, on the road from Sparta to Gythium, and about two miles from the modern village of Levétzova, in Laconia. The stone is of a dark grass-green, strewed with little parallelograms of a lighter green, sometimes approaching white and sometimes yellow. Procopius compares its color to emerald, and Statius and Sidonius call it a grass-green. Eurycles, the Spartan architect, used this stone in decorating the baths of Neptune at Corinth; and it was quarried to a large extent by the Romans, who enriched the monuments of Greece, Italy, and Gaul, with it.

The Augustan and Tiberian marbles, so fashionable in Rome under those emperors, were obtained in Egypt. They are breccias composed of fragments of greenstone, gneiss, and porphyry, cemented with a calcareous paste. They are similar in color, a bright green, spotted and streaked with dark green, reddish gray, and white; the only difference being, according to Pliny, that in the Augustan the figures undulate and curl to a point, while in the Tiberian the streaks are not involved, but lie wide asunder. It is probable that these marbles were quarried in the mountains between Thebes and the Red Sea. Inscriptions in the ancient quarries there, near the well of Hammamat, show that they were worked in the sixth dynasty of Manetho. A green marble called Memphites was quarried near Memphis in Egypt.

There were many other varieties of green marble known to the ancients, such as the red-spotted green antique, having a dark-green ground marked with small red and black spots and white fragments of *entrochi;* the *marmo verde paglioco*, yellowish green; and leek marble, of the color of a leek; but they exist only in small fragments, and their quarries are unknown. Another variety of green marble was found in the island of Tenos.

A blue marble is said to have been obtained in Libya. The island of Naxos yields a dark blue elegantly striped with white, Tenos a light blue veined with dark blue, and Scyros many kinds of blue and violet breccias, with other colors variously disposed. Scyros was one of the chief places whence the ancients derived their variegated marbles, and its quarries furnished many varieties closely resembling the famous marbles of other localities. Strabo says it pro-

duced the Carystian, Deucalian, Synnadic, and Hierapolitic marbles. The quarries of Tenos are still worked to some extent, but those of Scyros and Naxos remain almost as the ancients left them.

Of the black marbles of antiquity that now called *nero antico*, or black antique, was the most celebrated. It is more intensely black than any marble now quarried, the black marbles of France appearing almost gray beside it. It occurs only in sculptured pieces, and its origin is unknown; but Faujas discovered a quarry which had been worked by the ancients, about two leagues from Spa, not far from Aix-la-Chapelle, the marble of which closely resembles the ancient specimens. The largest masses known of *nero antico* are two columns in the church of Regina Cœli at Rome, but there are also some fine specimens in the Museum of the Capitol and in other collections. Some suppose it to be identical with the *marmor Lucullum*, which was introduced at Rome by Lucullus in the first century B. C., according to Pliny from Melos (another reading is Chios), but according to other authorities from Egypt or Libya, whence it is sometimes called *marmor Libycum.* Pliny says that Marcus Scaurus had pillars of it thirty-eight feet high in the atrium of his house. The Chian marble, a deep, transparent black, sometimes variegated with other colors, was quarried on Mount Pelinæus, in the island of Chios. A fine black marble was quarried on Mount Tænarus, in Laconia, and in the island of Lesbos, and a blue-black marble in Lydia. One of the most beautiful of the antique breccias, the African breccia, has a deep-black ground, variegated with fragments of grayish white and deep red or purplish wine-color. The grand antique breccia consists of large fragments of black marble united by veins of shining white. Columns of this and of African breccia are in the Paris Museum, but their quarries are unknown.

ON THE WONDERFUL DIVISIBILITY OF GOLD AND OTHER METALS.

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IT is both curious and interesting to notice how frequently original investigators, working from different standpoints, and with entirely dissimilar objects in view, will, independently of each other, accumulate a mass of observations corroborative of some one physical law, but which require to be collated in order to reveal their mutual relations.

The motive of this paper is to collect together several observations illustrating the divisibility of gold (made either as the direct

object of experiment, or as incidental to other investigations), and to present them in a condensed form to the readers of The Popular Science Monthly.

Some of these experiments (notably those of Faraday) present the curious anomaly of revealing to the physical sense of sight particles of matter which are almost too infinitesimal for the mind's eye to conceive, thus seeming to reverse the order of scientific investigation which usually prolongs the mental vision far beyond the region of possible physical revelation.

The experiments to be described have been arranged in the following order:

1. On the natural dissemination of gold.
2. Beating into thin leaves.
3. Faraday's researches.
4. Depositing by the galvanic battery.
5. Vaporization by the electric spark.

Some years since a very interesting series of experiments was made by the late Mr. J. R. Eckfeldt, then chief-assayer of the mint at Philadelphia, and his associate, Mr. W. E. DuBois (the present incumbent), upon the "Natural Dissemination of Gold." The results were presented to the American Philosophical Society, in the form of a paper, by Mr. DuBois, and published in their "Proceedings" of June 21, 1861.

The precious metal was found disseminated in marvelously fine division through a number of substances where its existence had not been previously suspected.

In the clay of which the Philadelphia bricks are made, gold was found in the proportion of about forty cents' worth to the ton. Each brick contains a sufficient amount of gold to make a glittering show of two square inches, if brought to the surface in the form of leaf.

An estimate of the thickness of the bed of clay under the city revealed the startling fact that more gold lies securely locked up in it than has been procured, according to the statistics, from Australia and California. A specimen of galena from Buck's County, Pennsylvania, yielded gold in the proportion of one part of gold in six million two hundred and twenty thousand (6,220,000) parts of ore; not quite ten cents to the ton. The report of these experiments concludes as follows: "Of this we may be confident, that the atoms of gold are homogeneously and equably dispersed through the clay, or other matrix; but by what natural process or for what final cause these fine particles should be thus diffused, seems quite beyond the reach of human philosophy."

The remarkable malleability of fine gold was a property well known to the ancients. Homer refers to the art of gold-beating, and Pliny mentions that an ounce of gold was beaten into seven

hundred and fifty leaves, "each leaf being four fingers square," or about three times thicker than our ordinary gold-leaf. On the coffins of the Theban mummies, gold-foil has been discovered of extraordinary thinness. The ancient Peruvians covered the walls of their temples with very thin sheets of gold, and the rude specimens of gilding on the palace of Tippo Saib, at Bungalore, prove that the art of gold-beating was practised in India. We also have Biblical authority for the antiquity of the art.[1]

Experiments made in modern times have shown that a single grain of gold may be beaten out so as to cover a space of seventy-five square inches; the thickness of the leaf is then only the three hundred and sixty-seven thousand six hundred and fiftieth ($\frac{1}{367650}$) part of an inch, or about twelve hundred times thinner than an ordinary sheet of printing-paper.

Faraday states in his researches on "The Experimental Relations of Gold (and other Metals) to Light"[2] that a leaf of beaten gold occupies an average thickness of no more than $\frac{1}{5}$ to $\frac{1}{8}$ part of a single wave of light. He reduced the thickness of gold-leaves at pleasure, by spreading them upon glass plates and gradually dissolving the metal by means of a weak solution of cyanide of potassium. "By this means," he says, "I think fifty or even one hundred might be included in a single progressive undulation of light."[3]

Faraday's researches upon the nature of thin films of gold and other metals, and upon the size of finely-divided particles of gold diffused through various liquids, are of a most interesting and refined character. Availing himself of the well-known reducing power of phosphorus, he floated small particles of it upon the surface of weak solutions of chloride of gold. In the course of twenty-four hours he found that the surfaces of the liquids were covered with films of metallic gold, which were thicker near the pieces of phosphorus "possessing the full golden reflective power of the metal," but becoming so thin by gradations as to be scarcely perceptible. "They acted as thin plates upon light, producing the concentric rings of colors round the phosphorus at their first formation, though their thickness then could scarcely be the $\frac{1}{100}$, perhaps not the $\frac{1}{500}$, of a wave-undulation of light."

By treating very dilute solutions of gold with phosphorus he obtained the metal diffused through the liquid in extremely fine particles, producing a beautiful ruby-color. These particles, "when in their finest state, often remain unchanged for months, and have all the appearance of solutions, but they never are such, containing, in fact, no dissolved but only diffused gold. The particles are easily rendered evident by gathering the rays of the sun (or a lamp) into a cone by a lens,

[1] "And they did beat the gold into thin plates" (Exodus xxxix. 3).

[2] "Philosophical Transactions," 1857.

[3] Faraday's "Researches in Chemistry and Physics."

and sending the part of the cone near the focus into the fluid; the cone becomes visible, and though the illuminated particles cannot be distinguished, because of their minuteness, yet the light they reflect is golden in character and seen to be abundant in proportion to the quantity of gold present. Portions of gold so dilute as to show no trace of gold by color or appearance can have the presence of the diffused solid particles rendered evident by the sun in this way. . . . The state of division of these particles must be extreme; they have not as yet been seen by any power of the microscope."

Faraday further tells us that he endeavored to obtain an idea of the quantity of gold in a given ruby fluid, and for this purpose selected a plate of gold ruby glass, of good full color, to serve as a standard, and he compared the different fluids with it, varying their depth until the light from white paper, transmitted through them, was apparently equal to that transmitted by the standard glass. Then, known quantities of these ruby fluids were evaporated to dryness, the gold converted into chloride, and compared, by reduction on glass and otherwise, with solutions of gold of known strength. "From these considerations it would appear that one volume of gold is present in the ruby fluid in about 750,600 volumes of water; and that, whatever the state of division to which the gold may be reduced, still the proportion of the solid particles to the amount of space through which they are dispersed must be of this extreme proportion. This accords perfectly with their invisibility in the microscope; with the manner of their separation from the dissolved state; with the length of time during which they can remain diffused; and with their appearance when illuminated by the cone of the sun's rays."

While all the statements of this profound investigator were so carefully kept within the limit of actual observation, he tells us, in conclusion, that he not only believed the gold to be diffused in solid metallic particles, but that he also believed "there may be particles so fine as to reflect very little light indeed, that function being almost gone."

The art of gold-plating has become so extensive in its application to a great variety of ornamental objects, that it seemed to the writer an interesting question "How thick a film is required to produce a fine gold-color?" He was unable to find, on inquiry, that any careful notes to determine this point have been recorded,[1] and he recently made some experiments with the following results: A sheet of copper was rolled down to an average thickness of $\frac{5}{1000}$ of an inch. Two plates were cut from this strip, 4 by $2\frac{1}{2}$ inches, having a metallic surface of twenty square inches each. These plates were boiled in alkali, to remove grease, polished, and accurately weighed on a bal-

[1] It is stated that when a cylindrical bar of silver is coated with gold and drawn into the fine wire used in embroidered housings, etc., a grain of gold will cover 345.6 feet of wire.

ance sensitive to the twentieth of a milligramme, or the $\frac{1}{1295}$ of a grain.

No. 1 weighed $126\frac{875}{1000}$ grains troy.
" 2 " $132\frac{85}{100}$ " "

A gold "blush" of sufficient thickness to produce a fine gold-color was then deposited by the battery. The plates were washed in distilled water, dried, and reweighed without rubbing, and were found to have each gained in weight exactly one-tenth ($\frac{1}{10}$) of a grain. It thus appears that one grain of gold may be distributed, by the galvanic deposit, over the surface of two hundred square inches, as contrasted with seventy-five square inches by beating. In other words, the metal is more than two and a half times thinner in the former case than in the latter, or $\frac{1}{980400}$ part of an inch, as compared with $\frac{1}{367650}$ of an inch.

A still thinner deposit of gold could, of course, be detected on the delicate assay-balance, but, owing to the transparency of the film, it would not possess the true gold-color. It seemed important to ascertain whether the gold was evenly distributed over the copper surface, or whether it was deposited in spots. The strips were accordingly examined under a microscope.

A careful examination showed that there were no exposed surfaces of copper, and the gold appeared to have a fine, bright, smooth surface. This, however, was not considered sufficient proof, and several expedients were tried to obtain the gold films free from the copper plate, in order that they might be examined by transmitted light. Owing to their extreme thinness this was difficult to accomplish. One method, which was partially successful, was to heat the copper plates to a cherry red in the annealing muffle of an assay-furnace. On cooling, the gold film peeled off in flakes with a thin backing of oxide of copper; these flakes were pressed between two plates of glass, and nitric acid allowed to flow in by capillary action. The acid dissolved the copper; leaving a film of free gold. The difficulty was, that the bubbles of gas formed perforated the film of gold. Another plan was then tried. The gold-plating was removed from one surface of the copper plates by means of fine emory-paper. Pieces about one inch square were immersed for several days in very weak nitric acid. The copper was entirely dissolved, and detached films of gold were found floating intact on the surface of the liquid; these were carefully collected on strips of glass, washed with distilled water, and dried; they then firmly adhered to the glass.

When examined by *reflected* light they retain their brilliant gold color and lustre, but when viewed by *transmitted* light they are bright green and very transparent; the color is an even shade, having none of the mottled appearance of gold-leaf when seen by transmitted light, caused by its very uneven thickness. This monotone appears to be a positive indication of uniform thickness, for, when two

films were superposed, one upon the other, the color was very perceptibly darkened; even when subjected to a magnifying power of 1,000 diameters the films retain their continuous character, though the brilliance of the green color is of course diffused. The dimensions of the waves of light, when decomposed by the prism, have been carefully measured. There are 47,000 green waves in the space of an inch; dividing the estimated thickness of our gold film by this number, we find that the thickness of the film is less than $\frac{1}{20}$ part of a single undulation of green light.

In the course of an examination made by the writer upon "The Practicability of assaying Metals used in Coinage, by means of Spectrum Analysis, made in and for the Assay Department of the United States Mint at Philadelphia,"[1] it was noticed that a large number of very powerful electric flashes might be passed between two slips of metal without any apparent loss, and an important query suggested itself, viz., whether the amount of metal vaporized by each spark was not too infinitesimal to be determined. In order to ascertain this point the following experiments were tried: Having weighed small electrodes averaging 18 milligrammes each with the greatest possible accuracy upon the gold assay-balance of the mint, which is sensitive to $\frac{1}{20}$ of a milligramme, or $\frac{1}{1295}$ of a grain troy, and having arranged a spark-register, it was found that 1,000 sparks might be passed between these poles, each spark showing the spectrum of the metal distinctly, and yet the loss in weight was too small to be made the base of calculation. Thus a gold pole lost in weight, after passing 1,000 sparks, $\frac{1}{1000}$ of a grain; this gives for each spark $\frac{1}{1000000}$ of a grain of gold, producing a bright spectrum.

The number was then increased to 3,000 sparks as the test. The loss of weight depends, of course, upon the electric volume, and in the experiments tabulated an endeavor was made to keep the latter constant. The tables (marked A and B) show that the loss in weight is marvelously small, averaging less than $\frac{7}{10}$ of a milligramme of gold for 3,000 sparks. To give the amount for each spark, this must be divided by the number of sparks; thus, in round numbers, an electrode loses $\frac{3}{1000}$ of a grain after passing 3,000 sparks; or, for 1,000 sparks, $\frac{1}{1000}$ of a grain; or, for each spark, $\frac{1}{1000000}$ of a grain. The experiments made by M. Cappel to determine the *minimum* amount of each element that would show a spectrum have been published in tabular form. His method was to volatilize "solutions of the metallic salts between the poles of a small induction-coil in Mitscherlich's glass tubes with platinum wicks. A series of solutions, each one-half the strength of the preceding one, was prepared from a number of metallic chlorides. The spectrum in connection with the positive pole was continually observed, while increasingly-concentrated solutions were

[1] Published in the "Proceedings of the American Philosophical Society," vol. xiv., p. 162.

brought in succession into the action of the spark until the lines of the substance were clearly visible." If a skeptical person refuse to believe the results of Cappel, who tells us that $\frac{1}{600}$ of a milligramme ($\frac{1}{38800}$ of a grain) of nickel will *just* write the signature of that metal, what will he say when, glancing at Table B, appended hereto, he finds the statement that $\frac{1}{60000}$ of a milligramme ($\frac{1}{3880000}$ of a grain) will sign its name *in brilliant characters!* And yet the writer does not hesitate to say that even a *smaller* amount of this metal will show a spectrum, for in these experiments a much stronger spark was used than was necessary to show a visible spectrum. When reduced to a minimum, by means of a miniature Leyden jar, improvised out of a test-tube, which still gave a distinct spectrum, the loss in weight, after passing 3,000 sparks, was *absolutely inappreciable* on the balance. The tables show another curious and unexpected result, viz., that the loss in weight of the volatile metals very slightly exceeds, and in some cases does not equal, the loss of the less volatile metals. Thus, in three different experiments of 3,000 sparks each, copper loses but $\frac{1}{10}$ milligramme, while gold loses $\frac{5}{10}$ milligramme."[1]

In one experiment the number of sparks was increased to 10,000, and the loss in weight was nearly proportioned to the increased number. In this case the sparks were passed at the rate of about 250 per minute.

TABLES.

The first column shows weight of metallic electrodes (in milligrammes) before passing the sparks.

The second column shows weight after passing 3,000 sparks.

The third column shows total weight of metal volatilized (in fractions of a milli gramme).

The fourth column shows the amount of metal volatilized by *each* spark (in fractions of a milligramme).

The fifth column shows the amount of metal volatilized by each spark (in fractions of a grain troy).

TABLE A.

	1.	2.	3.	4.	5.
Upper pole, gold	16.6	15.9	.7	$\frac{1}{4286}$	$\frac{1}{277000}$
Lower " "	16.7	16	.7	$\frac{1}{4286}$	$\frac{1}{277000}$
Upper " copper	18.5	18.4	.1	$\frac{1}{30000}$	$\frac{1}{1940000}$
Lower " "	18.5	18.4	.1	$\frac{1}{30000}$	$\frac{1}{1940000}$
Upper " gold and copper	24	23.4	.6	$\frac{1}{5000}$	$\frac{1}{324000}$
Lower " "	24	23.4	.6	$\frac{1}{5000}$	$\frac{1}{324000}$
Upper " tin	20	19.6	.4	$\frac{1}{7500}$	$\frac{1}{486000}$
Lower " "	20	19.4	.6	$\frac{1}{5000}$	$\frac{1}{324000}$
Upper " silver	24.8	24.6	.2	$\frac{1}{15000}$	$\frac{1}{976000}$
Lower " "	25.1	25	.1	$\frac{1}{30000}$	$\frac{1}{1940000}$
Average lead	91.6	90	1.6	$\frac{1}{1870}$	$\frac{1}{121000}$

[1] "The Spectroscope in its Application to Mint-Assaying." *Journal of the Franklin Institute*, October, 1874. Reprinted in the *Quarterly Journal of Science*, January, 1875.

TABLE B.

	1.	2.	3.	4.	5.
Upper pole, gold	20.5	20	.5	$\frac{1}{6000}$	$\frac{1}{388000}$
Lower " copper	10	9.9	.1	$\frac{1}{30000}$	$\frac{1}{1940000}$
Upper " gold and copper	21	20.4	.6	$\frac{1}{5000}$	$\frac{1}{324000}$
Lower " copper	20.2	20	.2	$\frac{1}{15000}$	$\frac{1}{976000}$
Upper " silver	6	5.8	.2	$\frac{1}{15000}$	$\frac{1}{976000}$
Lower " tin	20	19.4	.6	$\frac{1}{5000}$	$\frac{1}{324000}$
Upper " nickel	12	11.95	.05	$\frac{1}{60000}$	$\frac{1}{3880000}$
Lower " "	12	11.9	.1	$\frac{1}{30000}$	$\frac{1}{1940000}$

While it is probable that (with the exception, perhaps, of Faraday's researches) we have not here indicated the *smallest* particles of metal which it would be possible to determine by the delicate means at our disposal, it is thought that the experiments recorded may prove interesting, as showing what has been, and what may be, accomplished in this direction; and, lest any incredulous reader should fancy that, when we speak of weighing the three million eight hundred and eighty-thousandth part of a grain of metal, we are toying with imaginary fractions, we would refer him to Sir William Thomson's estimate of the size of the final molecules;[1] compared with which this unit is as large as the famous Philadelphia cobble-stones compared with grains of sand upon the sea-shore. In conclusion, we are led to appreciate the wisdom as well as the wit of the distich—

> "E'en little fleas have lesser fleas upon their backs to bite 'em;
> And these again have lesser fleas, and so—*ad infinitum.*"

MOVEMENTS OF JUPITER'S CLOUD-MASSES.

By RICHARD A. PROCTOR.

If Jupiter be regarded as a planet resembling our earth in condition, we find ourselves compelled to believe that processes of a most remarkable character are taking place on that remote world. It is singular with what complacency the believers in the theory that all the planets are very much alike accept the most startling evidence respecting disturbances to which some among those brother worlds of ours must needs on that hypothesis have been subjected. Mighty masses of cloud, such as would suffice to enwrap the entire globe on which we live, form over large regions of Jupiter or Saturn, change rapidly in shape, and vanish, in the course of a few minutes; and many are content to believe that what has thus taken place resembles the formation, motion, and dissipation, of our own small clouds,

[1] He fixes the limit between the $\frac{1}{2500000000}$ and the $\frac{1}{5000000000}$ of an inch, and says that they are "pieces of matter of measurable dimensions, with shape, motion, and laws of action; intelligible subjects of scientific investigation."

though the sun pours but about a twenty-seventh part of the heat on Jupiter, and but about a hundredth part on Saturn, which we receive from his rays. The outline of Jupiter, as indicated by the apparent position of a satellite close to his disk, expands and contracts through thousands of miles, yet the theory that Jupiter is still intensely hot must not for a moment be entertained, though the expansion and contraction of the solid crust of a cool planet through so enormous a range would vaporize a portion of its mass exceeding many times the entire volume of our earth. Saturn is seen by Sir W. Herschel and Sir J. Herschel, by Sir G. Airy, Coolidge, the Bonds, and a host of other observers, to assume from time to time the square-shouldered aspect, a change which—to be discernible from our distant standpoint—would imply the expansion and contraction of whole zones of Saturn's surface through 4,000 or 5,000 miles at least; yet it is better to believe that these stupendous changes have affected the solid crust of a planet like our earth than to admit the possibility that the outline we measure is not that of the planet itself, but of layers of cloud raised to a vast height in the deep atmosphere surrounding a planet still glowing with its primeval fires.

The phenomena I am now about to consider belong to the same category. They are utterly inexplicable, or only explicable by the most sensational assumptions as to the processes taking place on Jupiter, if we adopt the old theory of Jupiter's condition; while if we regard Jupiter as an intensely-heated planet surrounded by and entirely concealed within a cloud-laden atmosphere several thousand miles in depth, they at once admit of the most simple and natural explanation.

It has, of course, long been known that the belts of Jupiter are phenomena of his atmosphere, not of his surface. The belts of lightest tint have been regarded as belts of cloud, and the darker belts as either the real surface of the planet seen between the cloud-belts, or else as lower cloud-layers, appearing darker because in shadow. Accordingly, when features of the belts have been watched in their rotational circuit, it has been clearly recognized that the rotation determined in this way is not necessarily or probably the true rotation of the planet itself. Further, it has been proved, beyond all possibility of question, that some at least among the spots upon the planet's belts have a motion of their own; for whenever two spots in different Jovian latitudes have been observed, it has been almost constantly noticed that the one nearer the equator has had a greater rotation rate than the other. Again, it has sometimes happened that instead of two spots, in different latitudes, a well-defined dark streak or opening, having its two extremities in different latitudes, has remained long enough to be observed during several rotations of the planet. In these cases it has been observed that the end of the streak nearest the equator has traveled fastest, not only absolutely, but in longitude, insomuch that the position of the streak has notably altered.

Thus, in February, 1860, Mr. Long, of Manchester, noticed across a bright belt an oblique dark streak. "Its position" (I quote from a paper of my own written six years ago, when as yet the theory now before us was in its infancy) "might be compared to that of the Red Sea on the globe of the earth, for it ran neither north and south nor east and west, but rather nearer the former than the latter direction. The length of this dark space—of this rift, that is, in the great cloud-belt—was about 10,000 miles, and its width at least 500 miles; so that its superficial extent was much greater than the whole area of Europe." It remained as a rift certainly until April 10th, or for six weeks, and probably much longer. It passed away to the dark side of Jupiter, to return again after the Jovian night to the illuminated hemisphere, during at least a hundred Jovian days; and assuredly nothing in the behavior of terrestrial clouds affords any analogue to this remarkable fact. "This great rift *grew*, lengthening out until it stretched across the whole face of the planet, and it grew in a very strange way; for its two ends remained at unchanged distances from the planet's equator, but the one nearest to the equator traveled forward (speaking with reference to the way in which the planet turns on its axis), the rift thus approaching more and more nearly to an east and west direction." The rate of this motion was perhaps the most remarkable circumstance of all. Mr. Baxendell, one of the observers of the rift, and one of our most experienced telescopists, thus describes the changes seen in the belt: "Since Mr. Long first observed the oblique streak on February 29th, it has gradually extended itself in the direction of the planet's rotation, at the average rate of 3,640 miles per day, or 151 miles per hour, the two extremities of the belt remaining constantly on the same parallels of latitude. The belt also became gradually darker and broader."[1]

Apart from the evidence afforded by this rift respecting the swift motions of the cloud-masses enwrapping Jupiter (for a velocity of 151 miles per hour exceeds that of the most tremendous hurricanes on our earth), it has always seemed to me that this one series of observations should suffice of itself to show that the phenomena of Jupiter's cloud-laden atmosphere are not due to solar action. For the rift itself continued, and the changes affecting it continued whether Jovian day was in progress or Jovian night. For one hundred Jovian days or more, and for one hundred Jovian nights, the great cloud-masses on either side of the rift remained in position opposite each other, slowly wheeling, but still continuing face to face, as their equatorial ends rushed onward at a rate fourfold that of a swift train, even measuring their velocity only by reference to the ends remote from the equator, and regarding these as fixed. Probably the cloud-masses were moving still more swiftly with respect to the surface of the planet below.

[1] Two pictures of this belt, as seen March 12, 1860, and April 9, 1860, will be found in my article on "Astronomy," in the "Encyclopædia Britannica," vol. ii., p. 808.

Of course, it is just possible that a great dark rift, such as I have described, might appear thus to change in position without any actual transference of the bordering cloud-masses. Mr. Webb, speaking of a number of phenomena, of which those presented by the great rift of 1860 are but a few, says that "they prove an envelope vaporous and mutable like that of the earth, without, however, necessarily inferring" (? implying) "the existence of tempestuous winds: even in our own atmosphere, when near the dew-point, surprising changes sometimes occur very quietly: a cloud-bank observed by Sir John Herschel, April 19, 1827, was precipitated so rapidly that it crossed the whole sky from east to west at the rate of at least 300 miles per hour; and alterations far more sudden are conceivable where everything is on a gigantic scale." It does not seem to me altogether probable that more rapid alterations would affect cloud-banks covering millions of square miles than occasionally affect terrestrial cloud-banks covering perhaps a few tens of thousands of square miles; on the contrary, as small terrestrial clouds change relatively in a far more rapid way than large ones, and these than cloud-masses covering a county or a country, so it would seem that the changes affecting our largest cloud-layers would be relatively far more rapid than those affecting cloud-masses which could (many times over) enwrap the whole frame of this earth on which we live. But apart from that, and apart also from the important consideration that all such processes as evaporation and condensation, so far as the sun brings them about, should proceed far more sluggishly in the case of a planet like Jupiter than in that of our earth, which receives some twenty-seven times as much heat from the sun (mile for mile of surface), it is utterly incredible that precipitation should have occurred so steadily and swiftly along one edge of the great rift, and condensation—with such exactly equal steadiness and swiftness—on the opposite edge, that, while the rift as a whole shifted its position during a hundred Jovian nights and days at the rate of 150 miles per hour, its sides should nevertheless remain parallel all the time. Such processes may be spoken of as possible, in the same sense that it is possible that a coin tossed fifty times in succession should always show the same face; but we do not reckon such possibilities among scientific contingencies.

But the motion of great rounded masses in the atmosphere of Jupiter is still more decisive as to the existence not only of a very deep atmosphere, but also as to the swift motions taking place in that atmosphere.

I would, in the first place, note that the very existence of belts in the Jovian atmosphere, and especially of variable belts, implies the great depth at which the real surface of the planet must lie below the visible cloud-layers. Atmospheric belts can only be formed where there are differences of rotational velocity. In the case of our own earth we know that the trade-wind zone and the counter-trade zone

owe their origin to the difference of absolute rotational velocity between the equatorial parts of the earth and parts in high latitudes. In the case of Jupiter the difference of this kind is not sufficient to account for the observed belts — partly because there are many, partly because they are variable, but principally because Jupiter is so much larger than the earth that much greater distances must be traversed in passing from any given latitude to another where the rotational velocity is so many miles per hour more or less. Combining with these considerations the circumstance that the solar action which causes the atmospheric movements from one latitude to another in the case of our earth is reduced to one twenty-seventh part only of its terrestrial value in the case of Jupiter, we must clearly look to some other cause for the difference of absolute rotational velocity necessary to account for the belts of Jupiter.

Now, it seems to me that we are thus at once led to the conclusion that the cloud-masses forming the belts of Jupiter are affected by vertical currents, up-rushing motions carrying them from regions nearer the axle, where the absolute motion due to rotation is slower, to regions farther from the axis, where the motion due to rotation is swifter, and motions of down-rush carrying them from regions of swifter to regions of slower rotational motion. This view seems certainly encouraged by what we find when we come to study more closely the aspect of the Jovian belts. The white spots—some small, some large—which are seen to form from time to time along the chief belts present precisely the appearance which we should expect to find in masses of vapor flung from far down below the visible cloud-surface of Jupiter, breaking their way through the cloud-layers, and becoming visible as they condense into the form of visible vapor in the cooler upper regions of the planet's atmosphere. Then, again, the singular regularity with which in certain cases the great, rounded white clouds are set side by side, like rows of eggs upon a string, is much more readily explicable as due to a regular succession of uprushes of vapor, from the same region below, than as due to the simultaneous up-rush of several masses of vapor from regions set at uniform distances along a belt of Jupiter's surface. The latter supposition is indeed artificial and improbable in the highest degree, and in several distinct respects. It is unlikely that several up-rushes should occur simultaneously, unlikely that regions whence up-rush took place should be set at equal distances from each other, unlikely that they should lie along the same latitude parallel. On the other hand, the occurrence of up-rush after up-rush from the same region of disturbance, at nearly uniform intervals of time, is not at all improbable. The rhythmical succession of explosions is a phenomenon, indeed, altogether likely to occur under certain not improbable conditions—as, for instance, when each explosion affords an excess of relief, if one may so speak, and is therefore followed by a reactionary process, in

its turn bringing on a fresh explosion. Now, a rhythmical succession of explosions from the same deep-rooted region of disturbance would produce at the upper level, where we *see* the expelled vapor-masses (after condensation), a series of rounded clouds lying side by side. For each cloud-mass—after its expulsion from a region of slow, absolute, rotational motion, to a region of swifter motion—would lag behind with reference to the direction of rotational motion. The earlier it was formed the farther back it would lie. Thus each new cloud-mass would lie somewhat in advance of the one expelled next before it; and if the explosions occurred regularly, and with a sufficient interval between each and the next to allow each expelled cloud-mass to lag by its own full length before the next one appeared, there would be seen precisely such a series of egg-shaped clouds, set side by side, as every careful observer of Jupiter with high telescopic powers has from time to time perceived.[1]

That these egg-shaped clouds are really egg-shaped—not merely oval in the sense in which a flat, elliptic surface is oval—is suggested at once by their aspect. But it is more distinctly indicated when details are examined. It appears to me that considerable interest attaches to some observations which were made by Mr. Brett in April, 1874, upon some of the rounded spots then visible upon the planet's equatorial zone. It will not be thought that I am disposed, as a rule, to place too much reliance upon the observations and theories of Mr. Brett, seeing that on more than one occasion I have had to call attention to errors into which, in my judgment, he has fallen. For instance, I certainly do not think he has ever seen the solar corona when the sun was not eclipsed, though I have no doubt he saw what he described, which he supposed to be the corona, but which was in reality not the corona. Nor, again, do I accept (though I do not think it worth while to discuss) his theory that Venus has a surface shining with metallic lustre, and is surrounded by a glassy atmosphere; though in that case, again, his description of what he saw may be accepted as it stands, and all that we need reject is his interpretation thereof. In the case of Jupiter's white spots, Mr. Brett's skill as an artist enables us to accept not only his observations, but his interpretation of them, simply because the interpretation depends on artistic, not on scientific, considerations.

"I wish," he says, "to call attention to a particular feature of Jupiter's disk, which" (the feature, probably) "appears to me very well

[1] Webb thus describes the egg-shaped clouds: "Occasionally the belts throw out dusky loops or festoons, whose elliptical interiors, arranged lengthways and sometimes with great regularity, have the aspect of a girdle of luminous, egg-shaped clouds surrounding the globe. These oval forms, which were very conspicuous in the equatorial zone (as the interval of the belts may be termed) in 1869–'70, have been seen in other regions of the planet, and are probably of frequent occurrence. The earliest distinct representation of them that I know of is by Dawes, March 8, 1851, but they are perhaps indicated in drawings of the last century."

defined at the present time, and which seems to afford evidence respecting the physical condition of the planet. The large, white patches which occur on and about the equatorial zone, and interrupt the continuity of the dark belts, are well known to all observers, and the particular point in connection with them to which I beg leave to call attention is, *that they cast shadows*—that is to say, the light patches are bounded on the side farthest from the sun by a dark border shaded off softly toward the light, and showing in a distinct manner that the patches are projected or relieved from the body of the planet. The evidence which this observation is calculated to afford refers to the question whether the opaque body of the planet is seen in the dark belts or the bright ones, and points to the conclusion that it is not seen at all in either of them, but that all we see of Jupiter consists of semi-transparent materials. The particular fact from which this inference would be drawn is, that the dark sides of the suspended or projected masses are not sufficiently hard or sharply defined for shadows falling upon an opaque surface; neither are they sharper upon the light background than upon the dark. The laws of light and shade upon opaque bodies are very simple and very absolute; and one of the most rudimentary of them is that every body has its light, its shade, and its shadow, the relations between which are constant; and that the most conspicuous and persistent edge or limit in this association of elements is the boundary of the shadow—the shadow being radically different from the shade in that its intensity is uniform throughout in any given instance, and is not affected by the form of the surface on which it is cast, whereas the shade is distinguished by attributes of an opposite character. Now, if the dark spaces adjoining the light patches on Jupiter, which I have called shadows, are not shadows at all, but shades, it is obvious that the opaque surface of the planet on which the shadows should fall is concealed; whereas, if they are shadows, their boundaries are so soft and undefined as to lead to the conclusion that they are cast upon a semi-transparent body, which allows the shadow to be seen, indeed, but with diminishing distinctness toward its edge, according to the acuteness of its angle of incidence. Either explanation of the phenomenon may be the true one, but they both lead to the same conclusion, viz., that neither the dark belts nor the bright ones are opaque, and that, if Jupiter has any nucleus at all, it is not visible to us. It is obvious that the phenomena I have described would not be visible at the time of the planet's opposition, and the first occasion on which I noticed it was the night of the 16th of April last."

This reasoning, so far as it relates to the laws of light and shade and shadow, is, of course, altogether sound. Nor are there any points requiring correction which in any degree affect the astronomical inferences deducible from what Mr. Brett actually saw. I may note that somewhat later Mr. Knobel observed the shadow of white cloud-

masses, and, as the shadow had not so much greater a length at that time, two months from opposition, as it had when the planet was much nearer opposition, he infers that the true explanation of the appearance has hardly been found. He appears to have overlooked the fact that the assumption made in the explanation is not that Jupiter has a semi-transparent atmosphere always equally translucent and penetrable to the same depth by the solar rays. When the shadow was shorter than it should have been, had the atmosphere been in the same condition as when Mr. Brett made his observation, it is probable that a layer of clouds interrupted the rays, and thus the shadow was much closer to the cloud-mass throwing it than it would have been had that layer not been there. Mr. Knobel's paper contains very striking evidence of the variability of Jupiter's atmosphere, or rather of the clouds which float in it. "The greater distinctness of the satellites when near the edge," he says, "is a curious phenomenon which has been repeatedly observed by astronomers, but which seems to require explanation." On an occasion described "the second satellite transited a dark limb which was" (seemed) "most dark near the centre, and fainter toward the edge, yet the satellite was almost invisible when on the darkest part of the belt, and was bright and distinct when the background of the belt was faintest." This practically proved that on the occasion in question the dark, central part of the belt seemed darker than it really was by contrast with the bright belts on either side, while the edge seemed lighter than it really was by contrast with the dark sky on which the planet was projected. In reality the part near the edge must have been darker than the part near the middle, or the satellite could not have appeared brighter when near the edge. No doubt the darkness near the edge (which, by-the-way, my friend Mr. Browning tested photometrically, and demonstrated, at my suggestion, eight years ago) was due to transparency, the darkness of the sky beyond being to some degree discernible through the edge. But this transparency is not always to be observed to the same degree, or through the same extent of Jovian atmosphere as to depth. Mr. Knobel proceeds, illustrating this the more effectively that he does so unintentionally: "The third satellite, on March 25, 1874, appeared as a dark spot when in mid-transit, and on nearing the edge appeared as a bright spot without trace of duskiness. But on March 26, 1873" (observe the difference of years), "the fourth satellite made the whole transit as a dark spot, and was not perceptibly less dark at egress than in mid-transit."

It appears to me demonstrated by the evidence thus far noted that in a semi-transparent atmosphere of enormous depth, surrounding Jupiter, there float vast cloud-masses, sometimes in layers, at others in irregular heaps, at others having well-rounded forms. These cloud-masses undergo sometimes remarkable changes of shape, often forming or disappearing in a very short time, and thus indicating the infe-

rior activity of the forces at work below them—in other words, the intense heat of Jupiter's real globe. As to the actual depth of the semi-transparent atmosphere in which these cloud-layers and cloud-masses float, it would be difficult to express an opinion. We do not know how many cloud-layers there are, how thick any cloud-layer may be, how great may be the depth of the vast rounded masses of cloud whose upper surface (that is, the surface remotest from Jupiter's true surface) we can alone see under favorable conditions. But we can indicate a minimum than which the atmosphere's depth is probably not less; and, from all the observations which I have examined as bearing on this point, I should be disposed to assign for that minimum at least 6,000 miles. I am strongly of opinion that in reality the depth of the Jovian atmosphere is still greater. I cannot doubt that Jupiter has a solid or liquid nucleus, though this nucleus—glowing, as it must be, with a most intense heat—may be greatly expanded; yet I should conceive that, with the enormous attractive power residing in it, containing as it must nearly the whole mass of the planet, its mean density cannot be less than that of the earth. Now, a globe of the mass of Jupiter, but of the same mean density as our earth, would have one-fourth of Jupiter's volume—the mean density of Jupiter, as at present judged, being equal to one-fourth that of the earth. The diameter, therefore, of such a globe would be less than the present diameter of Jupiter, in the same ratio that the cube-root of unity is less than the cube-root of 4, or as 1 is less than 1.5874. Say, roughly (remembering that the atmosphere of Jupiter must have a considerable mass), the diameter of Jupiter's nucleus would, on the assumptions made, be equal to about five-eighths of his observed diameter, or to about 53,000 miles. This is less than his observed diameter by about 22,000 miles, so that the radius of his nucleus would be less than his observed radius by about 11,000 miles—which, therefore, would be the probable depth of his atmosphere.

But we have still to consider the velocities with which rounded masses of cloud travel in the very deep atmosphere of Jupiter. "There is clear evidence," I have pointed out in the article "Astronomy" of the "Encyclopædia Britannica," "that spots on Jupiter are subject to a proper motion like that which affects the spots on the sun. Schmidt, in No. 1,973 of the *Astronomische Nachrichten*, gives a number of cases of such proper movements of spots, ranging in velocity from about seven miles to about 200 miles an hour. It may be noted, also, that from a series of observations of one spot, made between March 13 and April 14, 1873, with the great Rosse reflector, a period of 9 h. 55 m. 4 s. was deduced, while observations of another spot in the same interval gave a rotation period of 9 h. 54 m. 55.4 s." The actual difference of velocity would depend in this case on the actual latitudes of the two spots, which were not micrometrically measured. Taking 200,000 miles as about the circumference of a

parallel of latitude passing midway between the spots (only a very rough calculation need be made), we should find that in a period of one rotation, or, roughly, of ten hours, one spot gained on the other about 51 seconds, or, roughly, about $\frac{1}{700}$ part of a rotation—that is, in distance (dividing 200,000 by 700) about 286 miles in ten hours, or nearly 29 miles an hour.

We have, however, instances of yet greater relative proper motion among cloud-masses. One of these cases I proceed to consider at length:

In June, 1876, two spots were visible upon the disk of Jupiter, so distinct and isolated as to be well adapted for measurement to determine the rate of the planet's rotation. Mr. Brett, observing them first as illustrative of the phenomenon to which he had called attention in 1874, turned his attention afterward to their rate of motion. He would seem not to have been aware of the fact that the proper motion of bright spots and other markings on Jupiter was already a recognized phenomenon; for he asks whether his "observations of these spots, forming a series extending over a period of 286 hours 20 minutes, afford evidence of proper motion, or whether, on the other hand, they tend to cast any doubt on the accepted rotation of the planet." However, his observations are all the freer from the bias of preconceived opinions. "There were several peculiarities about these two spots," he says, "which seemed to me to give them an eminent claim to attention. They occurred very near to the equator, and were very well defined, and free from entanglement with other markings—an advantage which they have maintained with singular uniformity throughout the period mentioned; but the special peculiarity to which attention is asked is, that during an interval of five days they remained in the same relative position without any variation whatever. Their stability in respect of latitude during those five days is undoubted; but the question is, whether or not they were equally stable in longitude. This remark only applies to the first five days of the series, because at the end of twelve days a certain deviation was obvious. The distance between the two spots occupied about 42° of Jovian longitude, or about 33,000 miles. Their diameter is nearly equal, being estimated at about one-fourteenth of the planet's diameter, or 6,310 miles." The interval of time between these first two observations "was 119 hours, that is to say, twelve rotations of the planet according to Airy's determination, during which time their distance apart and their latitude remained constant." Between the first and second observations the two spots had gained "44 m. 6 s. in time. Assuming Airy's rotation, viz., 9 h. 55 m. 21 s., the spots have gained on the planet's surface at the rate of 4 m. 2 s. in each revolution."

Between the second observation and the third "there was an interval of seven days, or seventeen rotations of the planet; and the

same two spots turn up again somewhat earlier than the calculated time. It unfortunately happens," proceeds Mr. Brett, "that on this occasion their configuration had undergone some change; but their dimensions and the distance between them remain very much as before. The most important circumstance respecting them is, that their rate of progress shows a certain acceleration." The change, however, in these seven days, is not such as to permit us to believe that the same pair of spots was under observation. *If* so, a change in latitude much more remarkable than the change in longitude had taken place; for the one which was the most northerly by about 6,000 miles at the beginning of the seven days was the most southerly by nearly the same amount at the end of that period. Considering that in the five days between the first and second observations no change of latitude took place, it may fairly be doubted whether a change of the kind, and so rapid, amounting, in fact, to nearly 900 miles per day, could have taken place in the interval. Proper motions in latitude may indeed be regarded as not less likely to occur in the case of Jupiter than in that of the sun, where they certainly sometimes occur; but all the observations hitherto made on Jupiter assure us that, in his case as in the sun's, proper motions in latitude would be very much slower than proper motions in longitude. We must be content with the evidence of proper motion afforded by the first five days of observation. (The fourth observation only followed the third by about twenty minutes.)

Now, taking this evidence as it stands, and making fair allowance for probable error in an observation of the sort, we may consider that during the 119 hours the two spots were gaining on the estimated rotation-period of the planet by about four minutes per rotation. As they both lie on the equatorial belt, we may take the circuit accomplished by each at about 267,000 miles, or, say, their rate at about 270,000 in ten hours, or 27,000 miles per hour. Hence, the distance traversed in four minutes would be about 1,800 miles, which would be about the gain per rotation. One-tenth of this, or 180 miles, would be the hourly gain, as compared with the estimated rotation-rate. Mr. Brett takes the least proper motion at 165 miles per hour.

He points out justly that the rotation-rate has been derived from observations of some such spots. So that in reality the only inference we can form is, that the rotation-rate derived from some spots is different from the rotation-rate derived from others, and that soms spots (if not all) are certainly not constant in position with respect to the solid nucleus of the planet. That the spots observed by Airy, Mädler, and others, should have indicated a slower rate of rotation than those observed by Mr. Brett, may fairly be ascribed to the fact that the former were at some distance from the equator, while the latter were nearly equatorial. For matter thrown up from the equatorial parts of the true surface of the concealed planet would manifestly

differ less in velocity from the superincumbent atmosphere into which they were driven than would masses expelled from higher latitudes. (It is probable that the same explanation applies also in the case of the sun.)

This conclusion, that the spots of Jupiter have rapid rates of relative motion, would of itself be of singular interest, especially when we remember that the larger white spots represent masses of cloud 5,000 or 6,000 miles in diameter. That such masses should be carried along with velocities so enormous as to change their positions relatively to each other, at a rate sometimes of more than 150 miles per hour, is a startling and stupendous fact. But it appears to me that the fact is still more interesting in what it suggests than in what it reveals. The movements taking place in the deep atmosphere of Jupiter are very wonderful, but the cause of these movements is yet better worthy of study. We cannot doubt that deep down below the visible surface of the planet—that is, the surface of its outermost cloud-layers—lies the fiery mass of the real planet. Outbursts, compared with which the most tremendous volcanic explosions on our earth are utterly insignificant, are continually taking place beneath the seemingly quiescent envelope of the giant planet. Mighty currents carry aloft great masses of heated vapor, which, as they force their way through the upper and cooler strata of the atmosphere, are converted into visible cloud. Currents of cool vapor descend toward the surface, after assuming, no doubt, vorticose motions, and sweeping away over wide areas the brighter cloud-masses, so as to form dark spots on the disk of the planet. And, owing to the various depths to which the different cloud-masses belong, and whence the up-rushing currents of heated vapor have had their origin, horizontal currents of tremendous velocity exist, by which the cloud-masses of one belt or of one layer are hurried swiftly past the cloud-masses of a neighboring belt, or of higher or low cloud-layers. The planet Jupiter, in fact, may justly be described as a miniature sun, vastly inferior in bulk to our own sun, inferior to a greater degree in heat, and in a greater degree yet in lustre, but to be compared with the sun—not with our earth—in size, in heat, and in lustre, and, lastly, in the tremendous energy of the processes which are at work throughout his cloud-laden atmospheric envelope.

Since the above article was written, news has been received by the Astronomical Society that Mr. Todd, a well-known observer of Adelaide, New South Wales, has been able to trace the motions of satellites behind the parts of the planet near the edge, or, in other words, *through* those parts of the planet's atmosphere which have hitherto been regarded as belonging to the mass of the planet itself.

TOADSTOOL-EATING.

By JULIUS A. PALMER, Jr.

I DO not mean in this article to consider the origin, reproduction, nature, and extent of the family of Cryptogamous plants called Fungi; for I do not claim the culture of the scientist, or the disinterested enthusiasm of the naturalist. "Art for art's sake" is not my war-cry. I propose to detail in popular language the experiences of an amateur toadstool-eater who desires to encourage personal investigation of a neglected subject.

Not long since, a course of lectures was announced on "Fungi." My call for circulars and tickets revealed the fact that the lecturer proposed to explain all about smut in distinction from potato-rot; the difference between blue-mould, black-mould, and white-mould, was also to be clearly defined, for which purpose a microscope of wonderful power had been provided. It seemed to me that, after people were able to tell healthful food from certain poison, it would be in place to give them a popular course on microscopic organisms.

Three years ago, I was detaching a large fungus from the famous Liberty-Tree on Boston Common. An over-cautious stranger tapped my shoulder and said, "My friend, that is not a mushroom!"

"Now that looks to me like a big toadstool," exclaimed another by-stander.

"Every mushroom is a toadstool, and every toadstool is a mushroom," I replied, and I repeat the answer here. You might as well call a beet a "vegetable," and every other representative from the garden a "plant," as to consider one fungus a "mushroom," and all others of a thousand species "toadstools."

Yet, people cannot be blamed for ignorance where there are so few sources of information. The difficulties experienced by the amateur can scarcely be overrated. Excepting the writings of Dr. Curtis, of South Carolina, I have not seen an original contribution to American literature on this obscure topic. Even Dr. Curtis (in a very interesting correspondence with Charles James Sprague, deposited at the rooms of the Boston Society of Natural History) gives little information regarding toadstools, devoting most of his letters to the revelations made by the microscope. I, however, procured from London the works whose titles I give in the note at the end of this paper, and began the study of fungology as a science.

Still, discrepancies and obscurities will confront the student. The descriptions are by no means exact. All these authorities describe fungi of foreign parts, i. e., not necessarily American species. The classification is not even harmonious, as the generic names of the different species vary with leading authorities, from the time of Sow-

erby to the present. When you have placed a specimen in the proper family, you have not in any way defined its quality, since one mushroom may be esculent, and its twin brother poisonous. Yet, the work of Berkeley is a book easily procured, and, having a number of colored plates, is readily understood by persons with botanical tastes. Such will find no study more fascinating. It is surprising how quickly the hand and eye acquire a delicacy in analysis, impossible to communicate in words. This talent is essential. No one should attempt to gather mushrooms who has not the power to fix in his mind the exact characteristics of any specimen, so as not to be in the least danger of confounding it with its nearest neighbor.

The student must sweep the brain clear of various charms and traditional lore. There is no magical way of identifying good mushrooms; no infallible test for healthful varieties. Here are some specimens of newspaper paragraphs:

"Every mushroom," says one (meaning every edible mushroom), "should peel like a potato."

Agreed, but nearly all the fungi peel readily.

"But the stem ought to come out like an umbrella-handle."

Whole classes (many of them noxious) have free gills, which is the only reason why the stem leaves the cap so easily.

Then, on the negative side, you will hear such attempts at classification as the following, taken from a widely-circulated weekly:

"As a general rule, all found in damp, dark places, or on decaying animal matter, are poisonous. Those that have a very thin cap, or the stem growing from the side instead of the middle, should be avoided. All milky mushrooms, with the single exception of the orange milk-mushroom, are extremely dangerous. So also are those which have the gills of equal length, those which run speedily into a dark, watery liquid, which taste bitter or burn the mouth, *or have a fetid, sickly smell.* If a mushroom turns a variety of colors when bruised, or is marked by the trail of a snail, it can under no circumstances be eaten."

Excepting, perhaps, the phrase I have italicized, the above is a tissue of misapprehension. Damp, dark places produce the very best mushrooms. The edible champignon (*Marasmius oreades*) has a very thin cap. The elm-tree mushroom (*Agaricus ulmarius*) has an eccentric stem. The brown milk-mushroom (*Lactarius volemum*) is unquestioned, and several others are doubtless esculent. A whole family (*Russulæ*) have equal gills. The maned mushroom (*Coprinus comatus*), most delicious, and easily recognized, turns to ink without the addition of any fluid. The honey-colored mushroom (*Agaricus melleus*) is very acrid raw, as are also others, equally harmless when cooked. Several esculent Agarics turn red when bruised, and many edible Boleti change color. I never saw a snail on a mushroom. Presuming that the writer means to refer to slugs, I would add that

I have often cut them out of mushrooms, rejecting only the part they had spoiled.

I have given but one example of each inconsistency, but they might be multiplied almost indefinitely. Then comes your believer in charms: dropping salt on the mushroom to see if it turns black or yellow, or stirring them with a coin spoon to watch for evidences of discoloration. Another rejects all which grow from wood. But no test of any kind, in form, color, or basis of growth, will distinguish healthful from harmful fungi.

"What, then?" despairingly asks an inquirer—"what, then, can be done?"

Exactly what is done in every other department from domestic economy to high art. How does Mr. Jarves tell the difference between a painting by Leonardo da Vinci and one by Guido Reni? How could you explain (to one who had never seen either) the difference between a hyacinth-bulb and an onion? From essays on the early painters, you draw conclusions which enable you to distinguish at sight the works of two artists. In kitchen-lore, the child acquires distinctions with its earliest lessons at the mother's apron-string. Only by these two means can practical knowledge of the kingdom of Fungi be increased: first, exact scientific analysis; second, the circulation of arbitrary, traditional information, such as saying to ignoramus:

"There, sir, that is an elm-tree mushroom; mark it well: whenever you find one just like it on your elm, eat it."

With a view of encouraging research, I shall make an attempt at an original but very limited classification, and also describe a few varieties of mushrooms. The first distinction is in the nature of the surface bearing the reproductive bodies or spores. Pick the next toadstool you find; look under the top or cap. You will observe one of four things:

1. There is a series of thin plates set on their edges running in to a common centre, like the spokes of a wheel. The spokes are called the gills; the stem corresponds to the hub. This is the largest family of mushrooms, the *Agaricini* or *Agarics*.

2. In the place of gills, your specimen may have a substance resembling fine sponge. It is then a pore-bearing mushroom, generically a *Polyporus*. Supposing the stem to be distinctly defined, of ordinary length, and the pores or tubes easily separable from each other, it is a *Boletus*.

3. Instead of the sponge, you may find a number of small points or spines. It belongs then to the teeth-bearing fungi, generically the *Hydnei*.

4. When you invert the mushroom, you may find neither gills, pores, nor teeth. It may be globular. In the three other classes, the spores are borne externally; here they are inclosed. If young, the

skin is filled with a substance, white, yellowish, purple, or black. If old, the contents are discharged in dust at a smart squeeze. It is a Puff-ball.

As the object of this article is to interest those having no knowledge whatever of the subject, I shall not allude to other families. It is probable that your toadstool will come within one of these four grand divisions. If not, select another at once.

The puff-balls are the safest mushrooms for the beginner. When you find one, with a smooth skin, perfectly white inside, it is the giant puff-ball (*Lycoperdum giganteum*) in an infantile state. The color of the skin varies from pure white to a shade almost black. If the knife leaves a stain of yellow, it is too old to eat. Otherwise, you may eat it without fear. There are several smaller varieties, which my wife and I eat indiscriminately.

I believe all white puff-balls may be safely used if cooked at once. They change very rapidly after gathering, and should only be eaten in their freshest state. There is no poisonous fungus resembling them.

The teeth-bearing toadstools are also safe fungi for the experiments of the amateur. I have found only one variety, but Smith says all the species of any size enjoy a good character. The spreading hydnum (*Hydnum repandum*) is usually yellow, sometimes reddish, always firm-fleshed; stem deformed, indistinct, or eccentric; and one side of the disk, or top, is frequently much higher than the point diametrically opposite. The peculiarity of the teeth, or spines (which in young specimens easily rub off), is enough to distinguish it.

The *Boleti* can only be confounded with their twin brothers, the *Polyporei*. The latter grow mostly on wood, with abortive stems, while the boletus of the edible kind grows from the ground, has a distinct stem, and the tubes of the sponge are easily separable from each other. If these tubes or pores are brown, yellowish, or greenish, the top being russet-color, or any shade of brown, and on cutting the flesh it remains white, it is an edible, or at least a harmless, variety. If the plant is brilliant-colored, red or yellow, or turns blue when bruised, it is best to reject it. If the tubes are red at the orifice, it is doubtless poisonous.

The *Agaricini* (those with gills) cannot be thus generalized, and I regard them as the least safe for the amateur, although it is to this class that the celebrated individual honored by English-speaking people with the title of "a mushroom" belongs. How can I describe this species, it varies so widely with its circumstances?

Two varieties, the meadow-mushroom (*Agaricus campestris*) and the horse-mushroom (*Agaricus arvensis*), run into each other by intermediate types so closely that professional cooks and gardeners may be forgiven that they entirely ignore any difference between them. There is a theory that the horse-mushroom is propagated from spores

of the meadow-mushroom after these latter have passed through the system of the horse.

At first, this mushroom resembles a puff-ball, but it soon discloses under the cap a veil or web, which ruptures and exposes the gills, free from the stem, with a faint shade of pink. This color deepens more and more, passing through purple into black. When pink, the ring around the stem is quite perfect, but I have found older specimens with not a trace of ring or veil. The top is every shade from pure white to deep brown; and, altogether, I can only advise the amateur to have one identified by an expert, if possible. Though difficult to describe, the taste and smell are so peculiar to the species that there is not much danger of deception when once you have made their acquaintance.

The most easily-recognized agaric is the maned mushroom (*Coprinus comatus*). When fit for food, it is the shape of a turtle's egg; that is, ovate, but alike at each end. The top is brown and smooth, but toward the earth the outer skin ruffles up, making a white mane or fringe of concentric layers around it. The stem is hollow, and on being cut appears, as it cooks, like macaroni. There is a ring round the stem, which is movable in the well-developed plant. Very soon after acquiring its growth the points of the gills turn black, sometimes running into pink; then it opens umbrella-like, and melts into an inky fluid. This was the first fungus we dared to eat on our own recognition, and has no poisonous counterpart. It should never be eaten either stale or having black gills, or when found around dust-heaps or other offal.

The second experiment was made on the elm-tree mushroom (*Agaricus ulmarius*). It grows only in fall on the elm, has a thick, solid stem (sometimes set in the side), broad white gills, firm white flesh, and a light-yellow top, at first smooth, finally spotted and cracked. Older, the gills turn yellow and the top very leathery. I know of no other large fungus with gills and white flesh growing from the elm. It is most common in a cleft, or where a limb has been sawed off, and often reappears yearly in the same spot.

The family of the *Russulæ* is quite safe for beginners. In the common mushroom you will notice the gills are pliable; the flesh also can be bent without breaking. The milk-mushrooms and the *Russulæ* are very brittle; the gills do not mat down like the horse-mushroom, or the elm-tree mushroom; they break into small pieces, while the whole fungus snaps suddenly on being bent. If milk or juice comes, I advise the amateur to reject the specimens. A novice should not attempt to cook them. If they are perfectly dry, taste a small piece. If it is not an edible russula, it will be likely to bite and sting the tongue, while all the esculent varieties of the genus are tasteless, mild, or with the flavor of chestnuts. There is one very common variety (*Russula alutacea*) with a bright-red top, buff-colored

gills, and stout, short stem. But two others (*Russula emetica* and *Russula rosacea*) resemble it so closely that, to this day, as I wash them, I invariably put a little piece of the stem of each into my mouth, in order to avoid all possibility of mistake.

I am in hopes to establish the truth of this theory: namely, that no fungus which, unspiced, being plainly cooked with dry heat, commends itself to the taste, can be dangerous to human life.

I advance this proposition with hesitation, because many people have so little sense in such matters. Mushrooms are mixed with gravies, fried in batter, simmered in fat, seasoned with black pepper or parsley-leaves, and their delicate flavor destroyed by compounding them with other food. The cook, thereby, disguises the very alarm which Nature has placed at the gateway. One of the most common signs of hurtful fungus is a stinging sensation affecting the tongue but little, the throat and tonsils more, and probably having the most effect upon the stomach and bowels. Let the mushroom absorb fat enough to cover this, or disguise the taste either by spice or by mixing one variety with another, and you may easily eat enough of a poisonous fungus to cause death.

Julie and I have tested perhaps forty varieties of toadstools; of these, we eat regularly, whenever found, considerably more than one-half, and are daily making additions to our bill of fare. Yet, I would not have the reader infer that we act carelessly. In whatever cause, reckless disregard of consequences is *not* bravery, although no two elements are oftener confounded. After tracing a specimen to its family, we broil it with the addition of salt and butter (no pepper), and eat a small piece on an empty stomach. We then increase the quantity in successive experiments until we feel perfectly safe, or experience unpleasant sensations. Usually, the non-edible fungus discloses its character over the charcoal: nauseous slime weeps from the stem, a grassy and disagreeable odor arises as it heats, or, on being tasted, there is no desire to take another mouthful. The intuition of woman, the cleverness with which the feminine mind grasps at an idea over which the stronger sex will reason mentally for hours, is nowhere more valuable than in the pursuit of this study.

We have never yet been deceived into making a meal of poisonous fungus. From the sparkling coprinus (*Coprinus micaceus*), a little toadstool very common about old stumps, and one or two other kinds, we have received evidence that condemned them as esculents. But we were once poisoned by some common mushrooms contaminated by being sent in a box containing a large number of another kind. The latter (*Coprinus deliquescens*) were in a state of decomposition. They eventually turn to ink, independent of contact with any fluid substance. In passing, I would say that the manuscript of this article is written with the result of such deliquescence. We had scarcely swallowed the edible ones before we felt the effects of the poison.

Our symptoms were not unlike those exhibited in a person using tobacco for the first time. Dizziness, nausea, purging, perspiration, with alternate cold spells, all passed over us within an hour, so rapid is the effect of the mushroom-virus. Two wineglasses of whiskey and sweet-oil (equal parts) neutralized the poison, and in a few hours we were no worse for the experience.

I would prescribe this remedy in all cases rather than the use of emetics. Omit the whiskey, if you please, or substitute vinegar for spirits, but take sweet-oil liberally in case of a mistake. I believe the Italians eat many dangerous fungi with impunity, because, when fresh, their properties are changed by sweet-oil; preserved, they are neutralized by pickle. Either of these elements renders harmless the peculiar alkali, to a superfluity of which mushrooms owe their noxious qualities.

We must use the same discretion daily employed in selecting other food. Who would willingly eat tainted meat? Is it so very uncommon to find a goose or duck too strong to be palatable? Who has not been poisoned by bad oysters, stale fish, or overripe fruit?

Because many mushrooms do not agree with the human system, it does not follow that they are deadly poisons. I have friends who do not pretend to distinguish varieties, but eat whatever has an appetizing flavor. (I do not consider this safe ground, because the inability to identify any one variety is doubtless the cause of many cases of poisoning.) Yet, although they claim to have made their breakfast from such obscurely known kinds as that which I afterward classified as the smeared cortinarius (*Cortinarius collinitus*), I have never known them to acknowledge any other sensation than an intense desire to hunt for more. Julie and I had one day eaten plentifully of the honey-colored mushroom (*Agaricus melleus*). On looking it up in Greville, a well-known Scotch authority, I found the following notice: "This species is said to be freely eaten on the Continent; at least Fries quotes the authority of Trattinick for the fact. But, on the other hand, Persoon gives it a bad character. In this he is supported by Paulet, who tried its effect upon a dog. The poor animal died twelve hours after receiving the poisonous fungus."

Notwithstanding such a warning, it continues to be a favorite article of diet with us to-day. I think it may be noxious raw, but that the heat kills the virus. It must be remembered that toadstool-eating is by no means an exact science. Fungus-eaters are daily making discoveries. Twenty years ago the two leading authorities of England and America, Berkeley and Curtis, considered the *Coprinus comatus* poisonous.

There are but two ways in which it is proper to cook mushrooms. By far the majority are best broiled on a fine-wire gridiron. They should be sprinkled with salt and (if the species is well known as an esculent) red pepper, buttered as the fire browns them. Otherwise,

stew them in milk, exactly as you would make an oyster-stew. The elm-tree mushroom, the honey-colored mushroom, and any others tasting raw of grass or trees, are only good broiled. The meadow-mushroom, horse-mushroom, or coprinus, are excellent cooked either way. There is no doubt of the wholesome character of esculent fungus. During the season, we eat them at our table three times a day; sometimes of a half-dozen kinds at a meal. We never enjoy better digestion than during toadstool-time. They furnish a natural alkali which in some systems is greatly needed.

We also dry them for use in winter. The Chinese and Japanese make dried fungus a very general article of diet. I speak here from personal acquaintance with their habits, acquired by a residence in San Francisco and Honolulu, as well as in their native land. No better substitute for meat than fungus can be found. Neither its odor when cooking, nor the gravy it makes, resembles any form of vegetable food. This is but natural, since the plant absorbs oxygen from the air, after the manner of animals.

Mushrooms grow above the ground, like any other plants. I have carefully watched all kinds, both in a natural state and when raised in my own closet. The common mushroom (supposed to spring up in a night, and which, says vulgar error, must be gathered with the dew on it) takes about ten days to mature from a button the size of a pin-head to a disk three or four inches in diameter, although most of this time the cap is just beneath the soil. This is the average period needed in acquiring perfection by other kinds, although some, as the *Coprinarii*, do not consume half that time.

NOTE.—Outlines of British Fungology, by Rev. M. J. Berkeley. London: L. Reeve & Co., 1860.

Handbook of British Fungi, by M. C. Cooke. London: Macmillan & Co., 1871.

A Plain and Easy Account of British Fungi, by M. C. Cooke. London: Robert Hardwicke, 1871.

Mushrooms and Toadstools. Illustrated with Two Large Charts. By Worthington G. Smith. London: Robert Hardwicke, 1867.

The Esculent Funguses of England, by C. D. Badham. London: L. Reeve & Co., 1870.

Fungi: their Nature and Uses, by M. C. Cooke. Edited by Rev. M. J. Berkeley. New York: D. Appleton & Co., 1875.

SKETCH OF PRESIDENT BARNARD.

AMONG the promoters of science and liberal culture in our time, few men have labored more efficiently and successfully than the present versatile and accomplished President of Columbia College. Although Dr. Barnard has done his share of original scientific work, it is not claimed for him that he has made any great discoveries;

nor could this be justly expected of a man whose life has been so absorbed in the work of educational reform, the progress of scientific culture, the organization and administration of collegiate institutions, and the furtherance of those higher measures and agencies of intellectual improvement which are never carried out except through the executive force and indomitable perseverance of a few men who are specially constituted for such tasks. Dr. Barnard has been untiringly busy in these important spheres of activity for nearly half a century, and seems still in the prime and vigor of his powers, and the meridian of his public influence.

Frederick Augustus Porter Barnard was born in Sheffield, Massachusetts, in the year 1809. He was educated at Yale College, where he graduated in 1828. He began his career as teacher by taking the position of tutor in that institution in 1829. In 1831 he went to Hartford, and engaged as instructor in the Asylum for the Deaf and Dumb; and, becoming interested in this branch of teaching, he subsequently pursued it in the Deaf and Dumb Asylum of New York. He afterward published an "Analytic Grammar, with Symbolic Illustrations," based upon a system he had originated for teaching the deaf and dumb, and which is still used in institutions devoted to their education. Dr. Barnard early chose the South as his field of labor, and in 1837 became Professor of Mathematics and Natural Philosophy in the University of Alabama, at Tuscaloosa, and subsequently took the chair of Chemistry in the same institution, which he held until 1854. The same year he took orders in the Protestant Episcopal Church. In 1854 he became Professor of Mathematics, Astronomy, and Civil Engineering, in the University of Mississippi, at Oxford, was elected its president in 1856, and promoted to its chancellorship in 1858. During his long residence at the South, Dr. Barnard devoted himself with great energy to the subject of education, both primary and academic, and advocated liberal and advanced views regarding college polity in several able reports. Never an opponent of classical culture, he freely criticised it, and strongly urged the claims of science to a larger and higher place in modern study than had been hitherto allowed. At the approach and outbreak of the civil war, President Barnard, remaining loyal to the Union, found himself embarrassed in his Southern position, and in 1861 he resigned his chancellorship and his chair in the university, and returned to his native North. In 1862 he was engaged in continuing the reduction of Gilliss's observations of the stars in the southern hemisphere. In 1863 he was connected with the United States Coast Survey, and had charge of chart-printing and lithography. Prof. McCulloch, who occupied the chair of Physics in Columbia College, New York, having left the institution and gone South to take his chances with the Confederate cause, Dr. Barnard became an applicant for the vacant position; but, instead of accepting him for this place,

the trustees of the institution elected him as its president in 1864, which office he still holds. Coincident with his accession to the presidency of Columbia College, an important step was taken by the managers of the institution for the promotion of scientific education by the establishment of the School of Mines, and the appointment of an able faculty to carry it on. This branch of the college has been so well administered as to become a great success. Its facilities for scientific training are ample and well directed, and in the number of its students it is already the rival of the classical department.

Dr. Barnard has written much upon both scientific and educational topics, and done a good deal of important work in connection with the various international expositions of industry, to which he has been commissioned by our Government. His last important literary undertaking has been the editorship of Johnson's "New Illustrated Universal Cyclopædia." He has received many honors from institutions of learning and leading scientific societies, both in this country and abroad, and has been President of the American Association for the Advancement of Science, of the American Microscopical Society, and of the American Institute, New York. The following are President Barnard's most important publications:

In the Journal of Science.

1. Aurora Borealis, 1838.
2. Improvement in Photography, 1842. (This was one of the earliest processes discovered for quickening the sensitiveness of Daguerre's iodized plates.)
3. Theory of Hot-Air Engine, 1853.
4. Modification of Ericsson's Hot-Air Engine, 1853.
5. Elastic Force of Heated Air, 1854. (A series of papers.)
6. Comparative Expansion of Heat in Different Forms of Air-Engines, 1854.
7. Mechanical Theory of Heat, 1854.
8. Examination of the Theory which ascribes the Zodiacal Light to a Ring surrounding the Earth, 1856.
9. The Eclipse Expedition to Cape Chudleigh, Labrador, 1860.
10. Hydraulics of the Mississippi, 1863.
11. Explosive Force of Gunpowder, 1863.

In the Proceedings of the American Association for the Advancement of Science.

12. On the Pendulum, with Description of an Electric Clock with Pendulum perfectly free, 1858.
13. On the Means of preserving Electric Contacts from Vitiation by the Spark, 1859.
14. Extended Report on the History, Methods, and Results of the American Coast Survey, 1859.
15. On the Assumed Identity of Mental and Physical Forces, 1868.

In the Reports of the Smithsonian Institution.

16. The Mathematical Principles of the Undulatory Theory of Light, 8vo, pp. 133, 1862.

In the Transactions of the American Institute.

17. The Metric System—History of the Movement in its Favor, 1871.
18. Theory of the High-Speed, Heavy-Piston Steam-Engine, 1871.

In the American Naturalist.

19. Description of a New Form of Binocular Microscope, 1871.

Published by the Trustees of Columbia College.

20. Essay on the Metric System—Examination of the Objections brought against it, and Discussion of the Values of its Units, with an Appendix on the Unification of Moneys, 8vo, pp. 194, 1872.

Published by the Senate of the United States.

21. Machinery, Processes, and Products of the Industrial Arts, and Apparatus of the Exact Sciences—Report on the Exposition of 1867, 8vo, pp. 669. 1868.

In "Field's Outlines of an International Code."

22. The chapters relating to Money, Weights and Measures, Longitude and Time, and Sea-Signals, 8vo, pp. 86, 1870.

Published by the Public Health Association of the United States.

23. On the Germ-Theory of Disease, 1874.

In the Journal of the General Convention of the Protestant Episcopal Church for 1871—*Appendix.*

24. On the Principles of the Ecclesiastical Calendar, with Concise Rules for finding the Movable Feasts, 1871.

In Johnson's Cyclopædia.

25. Numerous articles on topics in Mathematics, Mechanical and Physical Science, and on miscellaneous subjects scattered through the published volumes, 1874–'75.

Among his educational papers may be mentioned: "Letters on College Government," 1854; "Report on Collegiate Education," 1854; "Art-Culture," 1854; "Improvements practicable in American Colleges," 1855; "University Education," 8vo, pp. 104, 1858; "Relation of University Education to Common Schools," 1858; "Studies best adapted to Early Culture and Preparation for College," 1866; "Elective Studies in College Education," 1872; "Analysis of Statistics of Collegiate Education," 1870; Annual Reports to the Trustees of Columbia College, 1865, *et seq.*—a series; and numerous papers on Deaf-Mute Instruction, 1832–'37.

CORRESPONDENCE.

INSECTS AND FLOWERS IN COLORADO.

To the Editor of the Popular Science Monthly.

UNDER the above heading, in the January number, Mr. Meehan calls for a list of the *Hymenoptera* and *Lepidoptera*, abundant enough to probably act as cross-fertilizers of flowers in the region observed by him—namely, from Denver to Golden City and Idaho Springs, through the South Park to Pike's Peak, thence returning to Denver direct.

In 1871 (the year of Mr. Meehan's observations) I spent the months of June, July, August, and September, entirely in the region mentioned, and devoted my time almost exclusively to the collection and observation of *Lepidoptera*. In no place outside of the tropics have I found a better collecting-ground, at least so far as diurnals are concerned, both as to variety of species and number of specimens. This abundance, however, is chiefly noticeable early in the season, as indicated by the number of specimens I was able to secure in the different months—namely, 1,792 in June, 1,483 in July, 607 in August, and only 43 in September.

Of insects of other orders I collected about 3,800 specimens; but very few of them were *Hymenoptera*, as I devoted only rainy days to the collection of insects other than butterflies. Several species of humble-bees were observed; these did not seem to confine their attention to any particular kind of flower.

At Idaho Springs, about the middle of August, I saw hundreds of *Noctuidæ* attracted by the lights of the hotel, and captured some sixty specimens. A noteworthy fact is that in the Alpine regions many *Noctuidæ* were diurnal in their habits. The most abundant species was *Heliothis Meadii* (Grote); these moths were found flying from flower to flower, or resting upon flowers both above and below the timber-line. The white-lined sphinx (*Deilephila lineata*) was also quite plentiful in some spots, and seemed quite partial to larkspur and similar showy flowers.

Certain diurnals of arctic types positively swarmed on many of the peaks—for example, *Argynnis Helena* (Edwards), and lower down several species of *Melitæa*, *Phyciodes*, and *Argynnis*, were constantly to be found at flowers.

I give a list of the more abundant butterflies, with the number of specimens of each species or genus taken, classing those occurring almost entirely at or above the timber-line as Alpine; those found mostly below 11,000 feet elevation as valley species—the species in the latter class which range above the timber-line to any great extent are designated by an asterisk (*).

Necessarily most of the collecting was done below the timber-line; hence the Alpine species were more abundant in individuals than the recorded number of specimens collected would indicate. None of the species are likely to have been introduced by the agency of man.

ALPINE SPECIES.

Colias Meadii	65
Argynnis (5 species)	190
Chionobas (2 species)	25
Erebia Tyndarus, variety Callias	62
Hesperia near Centaureæ	16

VALLEY SPECIES.

Parnassius Smintheus *	241
Pieris (3 species)	106
Anthocharis (2 species)	79
Colias (5 species)	339
Vanessa, Grapta, etc. (9 species)	138
Argynnis (8 species)	210
Euptoieta Claudia * (very abundant)	52
Melitæa and Phyciodes (8 species)	297
Satyridæ * (7 species)	495
Lycænidæ * (21 species)	835
Hesperidæ	219
Geometridæ and Noctuidæ *	318

THEODORE L. MEAD.

CORNELL UNIVERSITY, *January* 20, 1877.

SINGING IN THE EARS.

To the Editor of the Popular Science Monthly.

MR. EDITOR: Do the minute tones heard in "singing" or "ringing in the ears" have any musical relation to each other?

"Singing in the ears" is a mingling of minute tones, somewhat like the singing of a tea-kettle, caused by undue pressure of the circulation in the head, etc.

In my own case, the minute tones seem to be *octaves*, and *thirds*, and *fifths* apart, forming chords and progressive intervals.

In investigating the relation of music to the physiology of audition, I find this a very important question, demanding a multiplicity of evidence. Will those of your readers who have information on this matter (positive or negative, but *exact*) write to me?

X. Y. CLARK,
Box 2,260,

SAN FRANCISCO, CALIFORNIA.

FEEDING-HABITS OF WOOD-ANTS.

To the Editor of the Popular Science Monthly.

IN the March number of your journal, page 634, is a notice of the "Singular Feed-

ing-Habits of Wood-Ants," wherein occurs the statement that, if the ants were immersed in water and placed on the ant-hills, they were invariably attacked by other ants as enemies, etc. This action is so at variance with what I have observed, that I will mention an incident which occurred while I was botanizing in Wisconsin last summer. In passing by a large stump I observed that the top was covered with large wood-ants. They were feeding on crumbs of bread left by some school-children. On the stump was a depression, where the ants were in large numbers. Procuring some water from a lake close by, I poured it into the depression, submerging several dozen ants. The most of them swam to the margin; others were in danger of drowning. What was my astonishment to see those who had escaped *rush into* the water, seize their drowning fellows, and drag them to the shore, where they tenderly turned them over until satisfied they were alive, when the rescuers went back and tried to save others! A few were dragged out too late—they were dead. These were turned over, felt of by the antennæ of the rescuers, and left for dead. In no instance was there any appearance of violence to the wet ants by the dry ones. The intelligence shown by these ants was greater than I had ever dreamed they possessed, and since that time I have had a most sincere respect for my lowly fellow-laborers.

E. M. Hale, M. D.

Chicago, *February* 24, 1877.

EDITOR'S TABLE.

MENTAL OVERWORK UNDER THE COMPETITIVE PRIZE SYSTEM.

THE death by suicide, not long ago, of a brilliant student of Cornell University, Emil Schwerdtfeger, at the age of nineteen, has a painful interest in connection with the subject of education. We are glad to see that the case has elicited some wholesome comment on the part of the press, in regard to the influences to which he was subjected, and the system of culture that supplies them; and we think the lesson that has been drawn ought to be enforced upon the public mind in the most pointed and emphatic manner.

It seems that the young man had fallen into a state of hopeless depression, after a course of successful study, in which he had made the most remarkable proficiency in the languages. His mental condition reminds us of that through which John Stuart Mill passed, when about the same age, after being subjected by his father to that long and terrible discipline of acquisition which is so fully described in his autobiography and has been curiously confirmed by a letter lately discovered, written by young Mill at the age of thirteen to Sir Samuel Bentham. After being crammed with knowledge in the most systematic way—dead languages, classical literature, history, mathematics, and political economy—from early childhood, by poring over books, until he became a perfect prodigy of erudition, he passed into a cloud of melancholy, in which his future life seemed vacant and hopeless. All the fountains of impulse that had previously incited him to effort seemed dried up in his gloomy dejection. He went on with his work mechanically, but without interest, while this portion of his life, or what he did in it, was afterward hardly remembered. He subsequently described his case in the following lines from Coleridge:

> "A grief without a pang, void, dark, and drear,
> A drowsy, stifled, unimpassioned grief,
> Which finds no natural outlet or relief
> In word, or sigh, or tear."

He was not free from suggestions of self-destruction which arise in such mental conditions, as we gather from the following remarks: "I frequently asked myself if I could, or if I was bound to, go on living, when life must be passed in this manner. I generally answered to myself that I did not think I could possibly bear it beyond a year." It was unquestionably a case of brain-

exhaustion, brought on by steady, prolonged, and severe mental application, and giving rise to the morbid condition of melancholia. His vigorous constitution, however, rallied and carried him through, although he had several relapses afterward. His education had been conducted as if his mind was a chamber to be packed with knowledge, rather than a force or activity dependent upon an organ of exquisite delicacy, which is liable to be strained, overworked, impaired, and broken down.

The tragical result in the case of Schwerdtfeger was due to two causes, from the operation of which Mill was comparatively exempt: he had slender health, and he was exposed to the artificial, high-pressure competitive system which is now so much in vogue in the sphere of higher education. He was a poor boy, of a highly-sensitive nature, intellectually precocious, and with an unhappy home, from the trouble of which he had only been able to escape through absorption in books and study. At fourteen or fifteen he was employed in an office to translate German works, and displayed such remarkable faculties that a wealthy gentleman thought he would give him a chance by sending him to college. He went to Cornell, at the age of sixteen, and, though not prepared to enter the university, took up his residence with one of the professors, and was quickly qualified for admission. No sooner had he got in than he began at once to be plied with the dangerous stimulation of the competitive prize system. A pecuniary reward was offered for the best essay on the "English verb." Our slender lad went in for it and won the prize and the honor, while yet a freshman, with abundant plaudits for his remarkable production. The distinction thus early achieved had of course to be sustained, and an extrinsic and artificial pressure was thus brought to bear upon the young man, who was thereafter expected to be an honor to the institution. He threw himself with all the premature ambition of a precocious nature into lingual studies—a class of studies that stands highest in the rank of collegiate scholarship, and that, therefore, brings most applause. It must be remembered, also, that the ascendency of these studies has long been defended on the ground that they afford the most available standards of acquisition, or the sharpest means of marking the student's progress; in other words, are best fitted of all subjects for racing and winning honors. Language after language was rapidly acquired. Schwerdtfeger bought a Greek grammar and stuck to it for ten hours a day, as we are informed, getting on with such proficiency that a distinguished Greek professor, from another institution, happening to be there, was set to examining him. After three or four hours of it, the professor declared that he was well prepared to enter the classical course of any college in the country, and was confounded when told that Schwerdtfeger had only begun Greek three weeks before. In languages he was ahead of any student who had ever been in the university. He gave lessons as tutor in Latin, Spanish, German, Greek, French, and Portuguese. Under this intense strain his health, originally poor, grew worse, and he ought then to have at once left the place. There is a moral discipline in such institutions which, if violated, entails expulsion; and it is a serious question whether there ought not to be a sanitary discipline, equally stringent, for the exclusion of students who damage themselves by over-study. But when the boy's health quite gave way under the stimulation of college influence, instead of being sent away, he was struck by a baneful agency from without. The Intercollegiate Literary Association offered prizes before the whole country for the best essay in Latin. The sick boy of Cornell entered into the competition, beat all his rivals, and won the

highest prize. He then lapsed into deeper morbid despondency, made his will, and shot himself through the head with a pistol.

We have here merely another instance, of which there have been thousands before, of the vicious working of that competitive system in our higher educational institutions, which should receive the inexorable reprobation of the community. Prof. Johannot writes to the *Tribune*, in relation to Schwerdtfeger's case, saying that Cornell University neither forces, crams, nor uses class-markings, which is all very well; but how about competitive prizes? Does it forbid these to its students? and, if not, is there no "forcing" here? Schwerdtfeger began and ended at Cornell by gaining prizes. If Schwerdtfeger "came to the institution an exceptional student, with a thirst for knowledge which was an absorbing passion, and had morbid fancies and an inherited tendency toward insanity and suicide;" if he was "fascinated with the life and fate of Chatterton," then the institution that took charge of him is to be all the more condemned for exposing him to the fatal stimulus of competitive prizes.

It is forgotten that we live in an age of excitement—a speculating, gambling, horse-racing age, feverish with political, religious, commercial, and sporting rivalries. All grades of society are infected by it, and the universal interest in it is such that the newspapers are crammed day by day with the details of competitive conflicts in numberless forms, from foot-races up to political campaigns. Against all this our higher education ought to make a stand. But, instead of doing so, the colleges, in various degrees, yield to the general tendency, and, in fact, avail themselves of the competitive spirit in carrying on their work. The pernicious effects of artificial excitements and provocatives are undeniable and notorious. Many have been sacrificed to this forcing system, through constitutional enfeeblement, prostration by disease, and premature death. For the natures upon which it takes effect are just those that are most liable to become its victims. Fatal results may not be produced, but shattered nerves and broken constitutions do follow everywhere upon the competitive prize system, because it is the readily impressible, the impulsive, and the unregulated, that are taken by its lures.

It is a physiological fact of the greatest importance in education that, under the stimulus of intense feeling and factitious excitement, the brain is capable of making rapid and extensive acquisitions, which are, of course, correspondingly transient. The cramming policy rests upon this capability of the brain, and it is this to which the competitive prize system appeals. It bids for immediate, striking, and showy results in acquisition, to be gained by exhaustion of the plastic power of this organ, and that, too, during the period of its growth, when the forces are required for enlargement and advancing organization. It violates this fundamental principle of education: that intellectual acquirement, to be permanent and valuable, must be slow; and that, for healthful mental development, knowledge, like food, must be taken as required by normal appetite, and become assimilated into faculty by the quiet, unforced processes of organic transformation. The protests in recent years against this policy have been many and emphatic, and much has been done to check it; but it will undoubtedly continue so long as partial parents continue to be imposed upon by the shallow parade of examinations, exhibitions, and prize-shows.

The Intercollegiate Literary Association now appears as a new force well calculated to thwart this beneficent tendency. It works by prizes and honors in their most mischievous forms, by blazoning the victories of students through all the newspapers in the land; so that

one might almost infer that the very object of its establishment is to encourage and strengthen the worst feature of educational practice. It is not an organization to improve the colleges by giving encouragement to neglected studies, or by bringing their schemes of instruction into completer harmony with the claims of modern knowledge or the necessities of modern life; but it offers its sensational rewards for proficiency in just those subjects which have long usurped undue attention in the collegiate education. It applies increasing pressure in those directions in which pressure is already excessive. Hence, if there are any students already shaken by struggles to get the leading positions in the colleges, the Association tempts them to come forward and fight it out with each other before the whole country. It will remain true to the end of time that those who sacrifice all the rest of their nature to the attainment of any one object will win it as against those who regard the claims of their whole nature. The Intercollegiate Association bids for the best cases of one-sided development. If a student has sacrificed his bodily health to brilliant scholastic results, the Association wants him for exhibition. Johannot says that Schwerdtfeger, "in preparing for the late intercollegiate contest, made no extraordinary effort;" yet he beat all the healthier fellows out of sight, and the Association gave him a prize for his disease. If it killed him, no matter; that was but an incident. Do not horses often die on the race-course? and are not men often killed in the prize-ring? Aspirants must take their chances. To the earnest protest of a correspondent to its encouragement of the Intercollegiate Association the editor of the *Tribune* replies, "Even if young Schwerdtfeger's death could be directly traced to overwork in connection with the recent competition in this city, we should hesitate before condemning the intercollegiate literary contests." This is a little startling as an illustration of the foothold that sporting ethics has got in the field of education; but we can admire that pluck of opinion which does not recoil from its logical consequences.

THE RELATIVE IMPORTANCE OF IDEAS.

WE picked up an educational paper the other day, presenting a long list of distinguished men as editors. This promised well, as the field of American education is not the place where the editorial "dummy" humbug would be tolerated. Albeit the wisdom of the periodical did not seem to be of a very solid sort, though we read on, hopefully expecting to find it at every step. At length we came upon the reviews of periodicals, and thought perhaps here we should discover the sound sense promised by the import of the editorial names. We found the story-telling magazines dissected, weighed, and measured, with care and fullness. The writer was here clearly interested in his topic; but when we came to THE POPULAR SCIENCE MONTHLY it was different. The writer said he never thought much of it, and, though he had no doubt there was some truth in Evolution, he did not like to have it thrust in his face and be bored with it perpetually in accordance with the usage of this periodical. This was the first time that he had broken out into adverse criticism. He had been hitherto much pleased; the contents of the story-telling magazines had not bored him. Whereat we reflected upon the different values assigned by different minds to different orders of ideas. We think the trashy love-sick stories, the idle gossip about notorious persons, and the dashing sensational criticism, which make up the chief portion of our literary periodicals, to be not very important; and on the other hand we think that Evolution, if true, is a very important matter indeed, and as the case stands it seems to us of very great interest to know what the ablest men of the age are thinking about it. Its establishment and general acceptance

must work the deepest and most far-reaching revolution in human thought of any truth to which the human mind has ever attained. Therefore we have taken some pains to keep our readers informed about it. And this was the more necessary, as the literary periodicals of large circulation pass the subject by, and the larger the circulation the more carefully is it ignored. They value, prefer, and select that which will "pay," and in so doing they cater, for mercenary purposes, to the caprice frivolity, prejudice, and ignorance of their readers, not troubling them much with the great and serious truths which science is working out for the world. It is gratifying to find that we are not singular in our estimate of the relative moment and significance of these two forms of intellectual occupation. A writer who gives elaborate consideration to President White's "Warfare of Science" in the *Westminster Review* opens with the following pungent observations:

"It has always seemed to us a matter for some wonder that people should take such a deep interest in the peddling events of poor individual human existences, and so little in the dynasty of ideas; that they should be content to wear their eyes out over the driveling three-volumed account of the loves and hates of vapid men and women, to indulge their finest emotions over the fifth act of some puling melodrama, and yet be altogether indifferent to the gigantic drama of truth in which the unity of place is the world, the unity of time the centuries, and the actors are beneficent truths or malevolent errors. Why men should be indifferent to these momentous events in the past which constituted the history of science, the history of philosophy, and, in the truest sense, the history of religion, and yet should enter with such eager zest into the gossip of the day and the trivialities of personal reminiscence, it is difficult to say. But, however hard it may be to discover the meaning of, there is no possibility of doubting, the fact. While the personal histories of men who have very small claims upon our better sympathies are read with avidity, the impersonal narrative of truths which have paramount claims upon our hearts and our heads are treated with the passive contempt of neglect. Men are much to us, while doctrines are little. We like to have our truths in the flesh; and we are too apt, when we find a doctrine incarnated, to neglect the sacred revelation and worship the man, to transfer the reverence which is due to an idea to the individual who is, as it were, the bearer of it. Here we have, in epitome, the history of many religions. Men will worship the truth with startled reverence, then they will worship the truth-bearer and overlook the truth in the symbol, and forget that of which it is the sign."

CONCERNING "BLUE GLASS."

We are asked why we do not discourse of Pleasonton and "blue glass." Why should we? Is it not abundantly considered by the press already? The object of our pages is to treat of subjects that are too generally neglected; to give expression to those great results of discovery and scientific thought which get but a meagre share of attention from the popular press, and we cannot find half room enough to do this work as it should be done. "But, really, what do you think of Pleasonton, and the blue-glass cure?" is now the obtrusive question. Well, we think that the man is a pestilent ignoramus, and his book the ghastliest rubbish that has been printed in a hundred years. He may be entirely honest, but that is no reason why we should give attention to his egregious folly. Pleasonton, however, it must be confessed, serves one important function: he gauges for us the depth and density of American stupidity. De Morgan says, somewhere, that certain men appear occasionally to play the part of "fool-ometers" in the community, that is, to measure the number and quality of the fools furnished by any given state of society. Pleasonton has done this for us with an accuracy that leaves nothing to be desired. Our showing in this respect is on a very handsome scale, fully commensurate with the length of the Mississippi, the sweep of the prairies, the glory of the Centennial Exhibition, the grandeur of the national debt, and

the splendid proportions of our system of education. He is a public benefactor, in that he has given us another "big thing." The interesting point just now about "blue glass" is psychological. It is an exponent of popular intelligence, an index of culture, a register of common-school work, and a test of the influence of colleges. Our collective schools produce in the community a certain state of mind; "blue glass" indicates it. There is evidently a very close connection here, and the problem deserves to be worked out. If the Intercollegiate Literary Association will offer an additional prize for the best essay on the connection between the study of Latin and Greek and the "blue-glass" mania, THE POPULAR SCIENCE MONTHLY will furnish the money for the purpose.

LITERARY NOTICES.

THE ENGLISH CONSTITUTION, AND OTHER ESSAYS. By WALTER BAGEHOT, Author of "Physics and Politics," Editor of the *Economist*, etc. Pp. 468. New York: D. Appleton & Co. Price, $2.

As we sit down to write a notice of this interesting volume, we are startled by the painful intelligence of the sudden death of its distinguished author. Mr. Bagehot was in the prime of life and the full vigor of his powers, as attested by the recent fertility of his pen and the sustained character of his intellectual work. His position as a writer was quite unique in the literature of our time. Strongly attracted to the study of public affairs, and devoting himself specially in his weekly journal to the consideration of economical and commercial subjects, he always dealt with them in a broad, philosophical spirit, and wrote upon them in a style of peculiar literary excellence, for which he was quite unsurpassed among contemporary writers upon these topics. Besides his contributions to the reviews, embracing close discussions of government policy and commercial economies, and his admirable biographical sketches, Mr. Bagehot is chiefly known by his volumes on "Physics and Politics," "Lombard Street," and "The English Constitution." This is his most important work, and that by which he will be best known in the future. The book on "Lombard Street" is a special study of the money question, but the "Physics and Politics," which was reproduced in French under the happier title of "The Development of Nations," and "The English Constitution," are of a wider interest, as they treat, in a scientific spirit, of social questions and phenomena that concern alike people of all countries. Those who have read the "Physics and Politics" will find "The English Constitution" treated by the same method; the principles there developed being applied to English constitutional history and the structure of English social life. We cannot, perhaps, give a better account of this work than by quoting the preface to the new American edition:

"'The English Constitution,' by Walter Bagehot, has already attracted some attention in this country, but it is a work that deserves to be much more widely and familiarly known. Its title, however, is so little suggestive of its real character, and is so certain to repel and mislead American readers, that, in bringing out a new and cheaper edition of it, at this time, some prefatory words may be useful for the correction of erroneous impressions.

"It is well known that the term 'Constitution,' in its political sense, has very different significations in England and in this country. With us it means a written instrument, decreed at a certain time to be the supreme law of the land. Hence when a book appears upon the American Constitution, if not a history of its adoption, it will probably be a commentary upon its meanings; that is, some kind of a law-treatise, dealing with the technical interpretations of a legal instrument. The English, on the contrary, have no such written document. By the national Constitution they mean their actual social and political order—the whole body of laws, usages, and precedents, which have been inherited from former generations, and by which the practice of government is regulated. A work upon the English Constitution, therefore, brings us naturally to the direct consideration of the structure and practical working of English political institutions and social life.

"The American Constitution was framed

by a convention; the English Constitution is a growth of centuries. Books written upon the two Constitutions are, therefore, likely to differ, much as a manual of carpentry differs from a hand-book of physiology; the former belonging rather to the province of constructive art, and the latter to that of natural science. While in the study of the American Constitution we are occupied with the 'intentions of the framers,' the 'rules of construction,' and the lore of lawyers, to get at the sense of a printed tract, the study of the English Constitution introduces us more directly to facts and phenomena, or the laws of political activity, social change, and national growth. These objects of inquiry obviously lend themselves to the scientific method of treatment, which aims to trace out the working of natural causes and inherent principles, and hence has interest for all students of political philosophy. Mr. Bagehot's work is written virtually, if not formally, from this point of view; it is pervaded by the scientific spirit, without taking on the technical forms of scientific exposition.

"With the author's inclination and capacity to regard public questions in their scientific aspects, many readers are already familiar through his suggestive volume entitled 'Physics and Politics.' 'The English Constitution' is a work of the same quality, and treats its subjects very much with reference to the principles of human nature and the natural laws of human society. It is a free disquisition on English polititical experience; an acute, critical, and dispassionate discussion of English institutions, designed to show how they operate, and to point out their defects and advantages. The writer is not so much a partisan or an advocate as a cool, philosophical inquirer, with large knowledge, clear insight, independent opinions, and great freedom from the bias of what he terms that 'territorial sectarianism called patriotism.' His criticism of the faults of the English system is searching and trenchant, and his appreciation of its benefits and usefulness is cordial, discriminating, and wise. He discusses old traditions and modern innovations, aristocratic privileges and democratic tendencies, with an absence of prejudice that comes from a predominant scientific temper of mind. Taking up in succession the Cabinet, the Monarchy, the House of Lords, and the House of Commons, he considers them in what may be called their dynamical interactions, and in relation to the habits, traditions, culture, and character, of the English people. The book, indeed, is full of instructive episodes, and sagacious reflections on the springs of action in human nature, the exercise of power by individuals or political bodies, the adaptation of institutions to the qualities and circumstances of the different classes who live under them, and numerous points of political philosophy, which are applicable everywhere, and have an interest for all students of political and social affairs.

"There is much in Mr. Bagehot's volume that bears very suggestively upon the state of things in this country. His comparison, in various points, of the working of cabinet government with that of presidential government raises questions regarding our own system which are forced into greater prominence by every decade of our national experience. But the book should be read by Americans not only for the interesting information it contains, and the brilliant light it throws upon the internal polity of a great nation from which we have derived so much of our own institutions, but because it will exert a widening and liberalizing influence upon the minds of our people, who are too apt to look upon all other governments with a kind of bigoted contempt. Our intense politics, chiefly occupied with selfish and sordid interests, and bitter personal rivalries, tend to exclude from this sphere of thought everything like science, or the large and liberal study of political principles. Narrow views lead to a depreciation of everything foreign that differs from our own system and practice. A distinguished professor in one of our leading colleges remarked that, when the students come up in their last year to acquire some notions of political science, their want of information relating to everything beyond the limits of their own country—their ignorance of anything like comparative politics—is to the last degree discreditable. Such narrowness is only to be corrected by travel and extended observation, or by cultivating those studies and reading those books that will give clear and just conceptions of the policy of other leading nations. Mr.

Bagehot's analysis of the English Constitution will be helpful to this end; and we doubt if there is any other volume so useful to our countrymen to peruse before visiting England. It will enable Americans to understand many things that at first perplex and disgust them in an old historic country, where all that most impresses the mind is so different from what we are accustomed to here.

"It remains further to say that Mr. Bagehot's work has a charming readableness that would not be suspected from its title or subject. It is written with an easy liveliness, a vivacious wit, and a felicity of style, that place it high in the scale of literary excellence.

"The studies of character of Brougham and Peel, that are appended to the present edition, and have not before appeared in this country, will be read with avidity, as they not only serve to throw additional light upon the modern politics of England, but give us an interesting insight into the intellectual life of two of the most conspicuous men who have figured in public affairs during the past generation."

THE SYNTHETIC PHILOSOPHY.

The Principles of Sociology. By Herbert Spencer, Author of "First Principles of Biology," "Principles of Psychology," etc., etc. Vol. I., pp. 734. New York: D. Appleton & Co. Price, $2.50.

The sixth volume of Spencer's "Synthetic Philosophy" is now before us. This great work was entered upon with many doubts as to its merits if executed, and many more as to whether it would ever get done at all. It has, however, moved slowly forward for the last fifteen years, against obstacles, both internal and external, which would have ordinarily brought such an enterprise to a stand long ago. The author's imperfect health has been a serious and constant impediment; the expensiveness of the undertaking has greatly imperiled its continuance; and the carelessness, stupidity, and downright perversity of reviewers, or those who undertook to interpret the system to the public, have been little calculated to inspirit the author in the progress of his work. Instead of welcoming with sympathy and intelligent encouragement a great effort like this to effect a higher unity of the different departments of knowledge, which modern science has begun to make possible, Mr. Spencer has been treated rather as if he had committed some grave offense against the interests of mankind. We have still large classes who look upon science with jealousy, and especially resent any effort to make it the basis of philosophy, or to develop it into a comprehensive and authoritative body of thought; and these classes have opposed and vilified from the commencement Spencer's work without scruple or reserve. It is gratifying to note that this unworthy feeling is giving way in many quarters, and is replaced by a growing disposition to do justice to his views; but in other quarters the old tactics of depreciation and misrepresentation are still pursued. We refer to the latest example. Our readers will remember that a year or two since the *British Quarterly Review* opened its columns to a very unmanly and vindictive assault upon Spencer, which had no excuse even under the largest license of decent reviewing. That there was some animus in the writer's mind quite apart from the fair and legitimate purpose of such work, was obvious enough at the time; but, if there could have been any doubt about it, that doubt is dispelled by the recent course of this *Quarterly*. In its January issue it contained another elaborate article professing to be a review of Spencer's "Sociology;" but the reader will hardly credit the statement that this work was not even referred to in the article. It was nothing less than an attack upon the old "Social Statics," a book published twenty-six years ago, and having in its preface to the later reprints an explicit warning to all readers that it does not contain a true representation of Mr. Spencer's present views. The course of the *Quarterly* was all the more outrageous, when it is remembered that Mr. Spencer had stated in this preface that the subject discussed in "Social Statics" would be reconsidered and placed upon a broader basis in the "System of Philosophy" upon which he has been at work since 1860. The writer in the *Review* added, in a note at the end of his article, that at the time it went to press the volume of Spencer's "Principles of Sociology" was

not yet published—a false statement, as it had been issued in quarterly parts during the past two years by Williams & Norgate, of London, the publishers of "Social Statics" and all the volumes of the "Philosophy." Though we may not expect in *British Quarterly Reviewers* any very high sense of honor, there is a barefaced recklessness in this proceeding which well illustrates the sort of treatment that Herbert Spencer has been receiving ever since he published the first volume of his "Philosophy" in 1862.

The readers of The Popular Science Monthly will hardly need to be told that the volume now published is the first of three which are intended to work out systematically the principles of the science of society. We have often explained the relation of these works to the philosophical volumes that have preceded them, and to the "Descriptive Sociology," which gives a comprehensive account of different types of the social state; and we have published various articles, from advance-sheets of the work itself, illustrating the quality and scope of the discussion contained in the volume before us. The work differs widely and profoundly from any that has ever appeared professing to deal with the subject of social science, and it is gratifying to see at last some cordial recognition of its great originality, value, and importance, from the leading critics of the English press. This is all the more satisfactory, that Mr. Spencer has conquered it against the steady pressure of a powerful and long-sustained antagonism. Having commented freely upon the work, and given illustrations of it, in the course of its publication, we prefer now to furnish our readers with the view taken of the completed volume by an influential London journal. The following is the notice that appeared in the *Pall Mall Gazette*:

"Those who have followed the development of Mr. Spencer's 'System' will have no difficulty in understanding the position held in it by the present volume. Hitherto he has been occupied in setting forth the laws of organic evolution, the 'Principles of Biology' having dealt with the physical aspect of that process, the 'Principles of Psychology' with its mental aspects. Both these works treat of the individual life of the organism; but when organisms come into relation to each other, form societies, and produce results which could not be achieved except by coördinated action, we are confronted by a new set of phenomena. We are in presence of what Mr. Spencer calls super-organic evolution. The task of sociology—it is now, we fear, too late to protest against the use of one of the most disagreeable words ever coined—is to interpret these new facts, to classify them, and to render intelligible the passage from one stage of progress to another. Among bees, wasps, and ants, we find the first indications of coöperation, associated with a certain degree of division of labor; and some of the higher types of vertebrata, such as rooks, combine in a still more marked manner. These instances of coördinated action are, however, of slight moment compared with the phenomena presented by human societies; it is, therefore, with the latter alone that sociology is concerned.

"The subject is so vast and complicated that it is difficult to treat of it without being either dull or superficial. Mr. Spencer, as those who know his writings would expect, escapes both dangers. As in his previous expositions, he confines himself to a few large principles; and these are so clearly expressed, so systematically arranged, and supported by so immense an array of proofs and illustrations, that readers wholly unaccustomed to philosophical inquiry may follow his argument with interest. Not even a German professor could have undertaken to bring together without help the enormous mass of materials which are here utilized. Mr. Spencer has had excellent assistance in collecting facts, and he has woven them with the skill of a master into a consistent and suggestive theory.

"In social evolution there are two factors: extrinsic and intrinsic. The former include all those outward influences, such as climate, surface, flora, and fauna, which determine human action; by the latter are meant the qualities of the units that make up society. Mr. Spencer devotes only one chapter to the extrinsic factors; but this suffices to indicate how many favorable conditions are necessary to the formation of a society, and how rarely these condi-

tions occur. As regards the internal factors, it clearly would not be enough to present the peculiarities of the civilized man, who inherits acquired tendencies and is to a large extent moulded by the society into which he is born; we must go back to the time at which physical forces were not controlled by intelligence, and when men lived together only in loosely-formed groups. All the world knows how Rousseau represented to himself the primitive man, and there are still, perhaps, people who affect to talk enthusiastically of the 'noble savage.' If we compare this sentimental conception with the picture drawn by Mr. Spencer, we are furnished with a tolerably accurate measure of the advance which has been made in the methods of investigating such subjects. The philosopher of to-day is not less fond of theory than his predecessor of the eighteenth century, but in his hands theory is never divorced from fact; it is incessantly brought to the test of reality, and in reality finds its only true starting-point. Hence, while Rousseau's idea could give rise only to a great many futile regrets and aspirations, Mr. Spencer's is the basis of a thoroughly scientific description of the long course through which mankind have passed from the simplest to the most complex forms of life. The primitive man is regarded in three different aspects: physical, emotional, intellectual. He is shown to have been, on the average, smaller than men now are, with limbs inferior both in size and structure, and a larger alimentary system, 'adapted to a very irregular supply of food, mostly inferior in quality, dirty, and uncooked.' Arriving early at maturity, he disliked change, and constitutional callousness made him insensible of evils which at a later stage become intolerable. The emotional characteristics of the savage are a 'wavering and inconstant disposition,' leading to an 'explosive, chaotic, incalculable behavior, which makes combined action very difficult,' extreme improvidence, selfishness modified only by a desire of admiration and by 'such fellow-feeling as results from that instinctive love of the helpless which he possesses in common with the inferior animals.' Intellectually the uncivilized man is on a level with the children of civilized parents. The perceptive faculties are keen, the reflective scarcely at all developed; like children, he has a strong mimetic tendency; he cannot concentrate attention on anything higher than simple facts; he has few general ideas, and being without any conception of natural order, he is incapable of rational curiosity or surprise. The question is sometimes asked, 'Why, if the human species has been so long in existence as the doctrine of evolution implies, did so many ages elapse before civilization arose?' No one who attentively considers these characteristics of the savage, and takes into account the outward difficulties with which he has to contend, will be surprised that man so long remained a slave to circumstances. The astonishing thing is, that any primitive tribes ever lighted upon the happy combination of conditions which enabled them to grow into progressive communities.

"In order to understand the institutions of civilized and semi-civilized societies, we must not satisfy ourselves with a general description of the faculties of the primitive man—we must investigate the ideas suggested to him by his experience. The chapters devoted to these are by far the most original and valuable in the present volume. It is common to judge savage conceptions by a reference to our more advanced knowledge, in the light of which they, of course, excite only surprise or amusement. Mr. Spencer, guided by the statements and hints of travelers, puts himself as much as possible in the position of primitive men, and looks at the world with their eyes; and the consequence is, that he succeeds in proving almost that their ideas were not only natural, but the sole ideas to which the evidence within their reach could have conducted them. One of the earliest of their theories is that of a second self. This arises, in the first instance, from dreams, the experiences of which the savage regards as real. He has no notion corresponding to that of mind; hence, when he dreams that he has been hunting or engaged in deadly conflict with an enemy, he never doubts on awaking that the incidents actually took place. Others testify that he has not moved; but this only shows that there must be a double which is capable of going away and having adventures of its own. He is untroubled by incongruities

that would perplex a more developed intelligence, for the facts seem to him beyond question, and he is familiar with many changes in Nature—the appearance and disappearance of clouds, the blowing of the wind, the waxing and waning of the moon—not at all less mysterious. His idea is confirmed by occasional instances of somnambulism; and the phenomena of swoon, apoplexy, and other forms of insensibility, are most readily explained by assuming that the body has been temporarily deserted by its ghost. In death the other self, which is upbraided before its departure by the friends of the dying man, says farewell; but it continues to exist, sometimes in its old haunts, sometimes in the neighboring woods, sometimes in the country whence the tribe originally came. It may even return to the body, and with a view to this contingency the latter is often carefully protected, and in many instances there are elaborate processes for arresting decay; if revival is dreaded, an exactly opposite course is pursued. In the earliest stages of development the ghost is a copy of the body, and may, like it, die; but tribes a little more advanced attenuate its substance until at length it is completely etherealized. It then has an enduring existence, and side by side with the world of the living is the more populous world of the dead. Ghosts continue to act as ordinary men, and are provided with food, weapons, canoes, horses, dogs. They are the cause of every unusual occurrence, and, entering bodies which they find temporarily vacant, occasion epilepsy and convulsions, delirium and insanity, disease and death. Every involuntary act, like sneezing or yawning, is due to them; and the necessity of controlling them gives rise to the class of exorcists and sorcerers. If friendly, they inspire the possessed, whose words are accepted as a revelation of higher wisdom. They are, of course, regarded with intense awe, and worship of them is, according to Mr. Spencer, the first manifestation of the religious sentiment. He goes much further than this, and finds in ancestor-worship the origin of all worship whatever. Idols are simply rude images of the dead, which ghosts are in some mysterious way believed to inhabit; hence food is given to them, and the family respectfully waits—that is, fasts—until they have eaten internally. A fetich is any object in which a ghost is supposed to dwell; and no object strikes the senses in a strange manner without having its peculiarity attributed to ghostly presence. This view of the fetich is not in accordance with current ideas; but it is confirmed by the fact that in cases in which the ghost-theory has not been evolved there is no fetich-worship, whereas the latter abounds where the former exists. But animals, plants, natural objects and forces, are also worshiped: how can these be in any way connected with ancestor-worship? Mr. Spencer applies his principle with unfaltering confidence even to these phenomena. Serpent-worship is the most general of all forms of animal-worship; it originates in the haunting of houses by certain kinds of snakes believed to be possessed by the ghosts of departed ancestors, who thus enter their old homes. In India the cobra is a common intruder in houses, and it is everywhere sculptured as a god; the Egyptian asp affords an instance equally remarkable. Bats and owls, which haunt caves and other burying-places, are also taken for metamorphosed ancestors. Some striking peculiarity will often secure for a man the name of an animal whose character his resembles. Unaccountable as it seems to us, the savage who hears his ancestor talked of as 'The Tiger' concludes that he is descended from one of those creatures; so that the tiger naturally becomes an object of reverence. The like is true of all animals, insignificant and strong alike, the names of which are applied to savages either in ridicule or respect by their neighbors. In this misapprehension of the meaning of words Mr. Spencer likewise finds the chief explanation of Nature-worship and plant-worship. A man is called Cotton or Tobacco, the Dawn, the Sea, the Moon, or the Sun. His descendants, taking the word literally, do not hesitate to regard the natural power or plant, whichever it may be, as their ancestor, and present it with the usual offerings. To civilized men this seems almost incredible; but it must be remembered that to the savage nothing seems impossible, because he has not attained to the idea of regular sequence in the world. And his language is so imper-

fect that he has no means of distinguishing after a certain interval between the literal and metaphorical application of words. With respect to anthropomorphic deities, Mr. Spencer argues that they are ancestors whose qualities are idealized and expanded.

"Ancestor-worship has never before been turned to such advantage in the interpretation of so many facts; and the ease with which the theory works gives it a certain charm. We see no reason, however, why Mr. Spencer should exclude every other cause in the production of early mythologies. The influences he has defined may all act as he describes; but they do not necessarily exhaust the sources of the religion of savages. He is as nearly angry as it is possible for so calm a thinker to be with 'the mythologists,' who represent uncivilized man as mistaking the names given to the forces and objects of Nature for the names of living beings. But surely this is not more strange than the process he himself has expounded, since in both cases the savage ends by finding in the outward world qualities which exist only in his own imagination. If he is unreasoning enough to suppose that the sun is his ancestor because his grandfather was so called, we need feel no surprise at his regarding the sun as alive merely on account of the effects it daily produces; and so of the moon, the dawn, or the wind. Mr. Spencer will not admit that the savage has any tendency to ascribe life to what is inanimate; but children constantly do so, and he insists that children and savages have a strong intellectual resemblance. We are not arguing for the theory which has been so persistently, if not always judiciously, advocated by Mr. Max Müller and Mr. Cox; we only say that within certain limits it may also be true. Religious phenomena are so complicated that it is improbable we shall be able to explain them by the modifications of any single principle.

"In several very interesting chapters Mr. Spencer uses the analogy between societies and organic bodies to illustrate the truth that 'social evolution forms a part of evolution at large.' He then passes to the domestic relations, in connection with which he discusses the many different forms of marriage and of marriage-ceremonies. To persons who believe that man has an intuitive perception of right and wrong in the relations of the sexes there could be no more suggestive study than that of exogamy and endogamy, promiscuity, polyandry, polygyny, and monogamy. Mr. Spencer does not so much argue against the intuitive theory as oppose to it the process by which, as a matter of fact, our present moral conceptions have been produced. This is, indeed, the characteristic of the whole work. Its method is throughout constructive; but for that reason it is much more effective in destroying popular doctrines regarding the origin and growth of many vital ideas than any amount of merely negative argument."

Electricity and the Electric Telegraph. By George B. Prescott. 564 Illustrations. New York: D. Appleton & Co. Pp. 978. Price, $5.

In this elaborate volume we have the detailed story of the telegraph, in a form suitable both for the instruction of general readers and for the guidance of those practically engaged in the art. The illustrations are copious and well executed, and all the curious complications of telegraphic mechanism, and the mysterious ways of electricity that are made available to the great end of the rapid transmission of intelligence, are described clearly and fully by the author. Mr. Prescott has been at great pains to bring forward the valuable contributions of foreign nations, especially the Germans, who have done more in telegraphy than they have had credit for, and his work may be commended for its comprehensiveness as well as that thoroughness of treatment which is indispensable to a first-class manual upon the subject.

Lessons in Electricity. At the Royal Institution. By John Tyndall, F. R. S. New York: D. Appleton & Co. Pp. 113. Price, $1.

For entering into physics through the experimental gateway, and by the use of simple apparatus, electricity has special advantages. Its experiments are simple, the effects distinct and striking, and the theoretical pathway to principles not difficult to follow, and well suited to exercise the reasoning powers. Dr. Tyndall has there-

fore done a most valuable service to science-teaching by preparing this little manual, which is admirably fitted to lay the foundation of an actual and thorough knowledge of the science. His experiments are ingeniously simple, and at the same time telling—each one carrying the pupil along a step further in his progress. The text is clear, pointed, compressed, and attractive, as Prof. Tyndall knows so well how to make it. But it is almost superfluous to call the attention of our readers to the excellences of this little work, as several portions of the earlier English edition have been already published in the pages of this MONTHLY.

PHILOSOPHICAL DISCUSSIONS. By CHAUNCEY WRIGHT. With a Biographical Sketch of the Author by CHARLES ELIOT NORTON. New York: Henry Holt & Co. Pp. 434. Price, $3.50.

THIS volume opens with a very pleasant and appreciative sketch of Mr. Wright by his friend Charles Eliot Norton, from which we gather that he was a gentleman of admirable personal traits which strongly attracted all who knew him. The book is made up of his literary remains, consisting of nearly a score of articles, contributed chiefly to the pages of the *North American Review* and to the *Nation* for the last fifteen years. They evince the strength of an able and independent thinker; but the style in which they are written is somewhat heavy. They are predominantly critical and controversial, as the author does not seem to have arrived at any constructive or systematic views of his own. He highly appreciated Mr. Darwin, and championed him against the criticisms of Prof. St. George Mivart, doing the work so well that it was thought important to republish it in London. There are many things in the articles of Mr. Wright that are well worth preserving, and his friends could in no way have better honored his memory than by collecting and publishing them in the elegant and substantial form which Mr. Holt has given to the volume. It should be mentioned that two of the papers, a fragment on "Cause and Effect," and the beginning of the article on Lewes's "Problems of Life and Mind," are published in this collection for the first time.

RUSSIA. By D. MACKENZIE WALLACE, M. A. New York: Henry Holt & Co. Pp. 620. Price, $4.

As the eyes of observers of international affairs are now turned upon Russia, there will be an increasing interest in all that relates to the domestic and social structure of that powerful empire. It is very rare that, at such a crisis of curiosity, there appears a work so eminently suited to satisfy it as in the present issue of Mr. Wallace's volume. It is a book that would make a mark and a sensation at any time, but the circumstances will now make it "the book of the season." Its author for the past six years has occupied himself with studying the people, the resources, and the institutions of Russia by personal observation and careful inquiry, residing in various cities and villages in different parts of the country, most favorable to varied and enlarged familiarity with the facts of which he was in pursuit. Mr. Wallace's book is written in good style, with no ambition for mere effect, but in the direct, common-sense way of a writer who has much to say, and goes directly to the point. His descriptions are graphic, without being wearisome, and the treatment of his special topics, though often full, occupies the reader closely to the end. It is full of important information, much of which is fresh and novel, in regard to the condition of the country, its peasant-life, the village communities, the larger towns and mercantile classes, imperial administration and local self-government, land proprietorship, the nobility, education, religion, church and state, military characteristics, emancipation of the serfs, the law-courts, the railroad system, social classes, industrial resources, the features of the country, and lastly, in the thirty-fourth chapter, the Eastern question, and the problem of territorial expansion. All these important subjects Mr. Wallace has handled with skill, and with constant reference to the great liberalizing tendencies of the age which are displayed in Russia as well as other leading countries, and under remarkable and peculiar conditions. Prefixed to the volume are two colored maps of Russia, one showing the density and distribution of the population, the railway system, and the grade of cities in respect to the number of their inhabitants; the other ex-

hibiting the distribution of the principal agricultural products. Any one who will familiarize himself a little with these maps, and then deliberately read the book, will probably get a great deal more knowledge than he could obtain by months of travel in the Russian Empire.

REPORT OF THE COMMISSIONERS OF AGRICULTURE FOR THE YEAR 1875. Pp. 536. Washington: Government Printing-Office.

OUR readers are not altogether unfamiliar with the matter contained in this "Report," for we have from time to time during the past year made selections from the monthly reports, especially of observations and experiments made by Mr. Glover and Mr. McMurtrie, respectively the botanist and the chemist of the department. These are repeated in the annual report, or, rather, they are bound up with it. The volume also contains papers on the forest-trees of the United States, varieties of fruits, alfalfa, the French mode of curing forage, hog-cholera, and several other subjects of interest to the agriculturist.

PROPERTIES OF CONTINUOUS BRIDGES. By C. BENDER, C. E. Pp. 150. Also, BOILER-INCRUSTATION. By F. J. ROWAN. Pp. 88. New York: Van Nostrand. Price, 50 cents each.

THE series of handy volumes on applied science to which these two treatises belong needs no commendation from us. The works are of a severely practical nature, and their merits are well understood by the engineers and mechanicians to whom they are addressed.

EFFECTS OF ALCOHOLIC POISON. By J. H. KELLOGG, M. D. Battle Creek, Michigan: *Health Reformer* print. Pp. 124. Price, 25 cents.

DR. KELLOGG attempts in this little pamphlet to discuss the question of alcohol in "its physical, moral, and social effects," and yet he finds room for a long chapter of twenty-seven pages on "Wine and the Bible," in which he wrestles manfully with such contradictory texts as those which call wine "cruel venom of asps," and those which say that "it maketh the heart glad."

THE JUKES: A Study in Crime, Pauperism, Disease, and Heredity. Also, Further Studies of Criminals. By R. L. DUGDALE, Member of the Executive Committee of the Prison Association, New York. With an Introduction by ELISHA HARRIS, M. D., Corresponding Secretary Prison Association. New York: G. P. Putnam's Sons.

THE title-page is itself a history of this remarkable work. To the student of the social sciences this pamphlet is a valuable contribution, giving as it does in tabulated details the lives of a family of large numbers, whose condition had become so fixedly criminal that harlotry, bastardy, and a career of law-breaking, ever gravitating prisonward, had become the inevitable heirship of the "Jukes," the word itself becoming a synonym of evil.

EARLY MIGRATIONS.—ORIGIN OF THE CHINESE RACE. Philosophy of their Early Development, with an Inquiry into the Evidences of their American Origin; suggesting the Great Antiquity of Races on the American Continent.

JAPANESE WRECKS, stranded and picked up adrift in the North Pacific Ocean, ethnologically considered.

EARLY MARITIME INTERCOURSE OF ANCIENT WESTERN NATIONS, chronologically arranged and ethnologically considered.

THE above are from the "Proceedings of the California Academy of Sciences," 1876; each has the common heading, "Early Migrations," and their author is Charles Wolcott Brooks. The pamphlets give evidence of large research, and are at least ingenious. The drift is toward the settlement of China from the American Continent, probably Peru. Is not the following statement made carelessly? "North American Indians have never been cannibals" ("Origin of the Chinese Race," p. 27). Do not the discoveries of the late Prof. Wyman, in the shell-heaps of Florida, speak to the contrary?

ADDRESS BEFORE THE ST. LOUIS ACADEMY OF SCIENCE, at its Annual Meeting for 1877, by the President, CHARLES V. REILEY. St. Louis, Mo.: R. P. Studley & Co.

AN interesting *résumé* of the year, in matters pertaining to the biological sciences, with, perhaps, a special attention to home work.

A Practical Treatise on Diseases of the Skin. By Louis A. Duhring, M. D., Professor of Diseases of the Skin in the Hospital of the University of Pennsylvania; Physician to the Dispensary for Skin-Diseases, Philadelphia; Author of Atlas of Skin-Diseases, etc. Philadelphia: J. B. Lippincott & Co. Pp. 600. Price, $6.

As a manual of dermatology for the medical practitioner this treatise will be found valuable and satisfactory. It is practical, thorough, and systematic, without claiming to be exhaustive, in the erudition of the subject, or the details of its historical literature. It presents the elements of the subject concisely, giving all the important facts in connection with each disease treated of. In classification Dr. Duhring follows the authority of the celebrated Prof. Hebra, of the University of Vienna, his former teacher, and to whom the present work is dedicated. A special and highly-commendable feature of Dr. Duhring's work is the definition of the various skin-diseases, which he has made out from the standpoint of clinical observation with a view to its practical usefulness, and which consists mainly of succinct descriptions of characteristic lesions and symptoms, where the cases were not too complex and obscure to make clear definition possible. In the sections devoted to treatment, while the author makes due reference to all those methods that are favorably regarded by the profession, he has also brought distinctly forward those remedies and modes of treatment that he has found of greatest benefit in his own medical experience.

Skin-diseases appear to undergo grave modifications in different geographical circumstances, so that well-executed treatises upon the subject in one country are liable to lose their accuracy when applied to other countries. On this point Dr. Duhring remarks: "I can but incidentally refer to the fact that disorders of the skin manifest more or less variation in type as they occur in one or in another part of the world. Having had some few years ago favorable opportunities for observing a large number of cutaneous affections in the various countries of Europe, and since then of studying these diseases in the United States, I can state that in many instances they differ materially in type as they are seen on the two continents. Without entering into this interesting subject, it may be remarked that the diseases met with here resemble more closely those of Great Britain than those of either France or Germany. A recognition of this fact must, I think, go far in accounting for the discrepancies which exist in the descriptions of certain diseases as given by trustworthy observers."

Ancient Pagan and Modern Christian Symbolism. By Thomas Inman, M. D. Pp. 174. With numerous Illustrations. New York: Bouton. Price, $3.

The exceedingly curious figures which abound in this volume give to it nearly all the value which it possesses. The book contains no less than 180 woodcut figures, together with 19 lithograph plates of full-page size. With hardly a single exception, they are more or less plainly symbolical of sexuality in religion. The author has undoubtedly rendered a great service to students of that particular aspect of the religious idea, by bringing together so many interesting memorials of the wide diffusion of sex-worship. His own remarks and speculations, however, do not carry much weight.

We reproduce some of the things said by the London *Examiner* in reference to Arnott's "Physics," which, in its new form, is attracting much attention:

"It was in 1827 that Dr. Arnott took the world by storm. The publication, in that year, of the first volume of the 'Elements of Physics' was probably the greatest 'sensation' ever made by a scientific work, purely as an exposition. The first edition was sold in a few days; a second had to be followed by a third, a fourth, and a fifth, in as many years. If the author had devoted himself to keeping it up by the necessary improvements, it would have long continued to distance all competition in its own walk. It had an equal run in America, and was translated into nearly all the Continental languages. The popularity of the book was not due to any meretricious qualities. There was an extraordinary profusion of interesting examples, but these interfered less than in almost any other popular work with the understanding of the doctrines—

in fact, were, as they ought to be, aids to the proper end of the teacher. The best proof of this was the number of individual minds that were stimulated to a scientific or intellectual career by the study of the work. The hearty testimony borne by Herschel and Whewell to the merits of the 'Physics,' scientific as well as expository, was incompatible with any infusion of claptrap.

"It would be easy to set forth the art, or rather the genius, of Arnott, in the composition of his book. He had great literary power, in the mere command of expression, and in the composition of his sentences, which are both lucid and flowing. Many scientific writers have had this much. But he had also a thorough and unfaltering perception of the intellectual capabilities of an average reader, and never for a moment presumed too much upon these. He labored, with no small success, to bring the doctrines of natural philosophy down to a level of mind that had never before been permeated by them; and, if any part of the subject was hopelessly intractable, he passed it by.

"Besides his amassed store of popular illustrations, stated in easy language, the work had the further charm of a species of sentiment or eloquence, often enough attempted in connection with science, but not often so well kept up. The author fully complied with Plato's condition of philosophical teaching—to exhibit the goodness of the divine plan of the Cosmos. His eloquent passages on this subject, together with his choicest illustrations of physical laws, were largely adopted into the common-school reading-books.

"The new editors have shown themselves aware of the backward state of the exposition in many parts, and have freely employed the power of excision and substitution. We should say, from a rough estimate, that a full half of the work is new. In the branches of Acoustics, Heat, Light, and Electricity, many additions were obviously necessary. In Mechanics, there has been more permanence, and Arnott's exposition is less interfered with; but it was essential to supplement his chapter on Motion and Force with a view of the doctrine of conservation of energy, which the author would have been delighted to handle in his own peculiar way, but scarcely touched upon even in his latest edition. However the work of revision may have been distributed among the three editors, they have been successful in bringing up the subjects to the most recent views, and in illustrating them by well-chosen examples and diagrams. The work is one likely to keep its place among treatises on a similar scale. Extending to nearly 900 pages, it comprises a tolerably full body of information in all the branches, while the reader has still the benefit of the expository genius and eloquence that charmed and astonished the world forty years ago, and has not yet been superseded."

PUBLICATIONS RECEIVED.

Proceedings of the Thirty-second Annual Meeting of the New York State Teachers' Association. 1876. *School Bulletin*, Syracuse, N. Y. Pp. 119.

On the Atmosphere of the Sun and Planets. By David Trowbridge, A. M. 1876. Pp. 7.

The Relations of Medicine to Modern Unbelief. By Richard O. Cowling, A. M., M. D. Louisville: John P. Morton & Co. print. 1876. Pp. 11.

Report of the Committee on Naval Affairs to the House of Representatives on a Bill to authorize and equip an Expedition to the Arctic Seas. Pp. 13.

Proceedings of the American Chemical Society. Vol. I., No. 2. J. F. Trow & Sons print. 1876. Pp. 49.

The *Western Review of Science and Industry*. Edited by Theodore S. Case. February, 1877. Vol. I., No. 1. Kansas City, Mo. Subscription, $2.50 per annum.

Milk-Sickness. By W. H. Philips, M. D. Pp. 21.

Twenty-sixth Annual Report of the Managers of the House of Refuge, made to the Governor of Maryland. Baltimore: Innes & Co. print. 1877. Pp. 28.

Check-List of the Fresh-Water Fishes of North America. By David S. Jordan, M. S., M. D., and Herbert E. Copeland, M. S. Pp. 31.

Rate of Set of Metals subjected to Strain. By Prof. Robert H. Thurston. Pp. 10.

Am I my Brother's Keeper? Discourse before the American Public Health Association, at the Annual Meeting in Baltimore, November 11, 1875. By Lewis H. Steiner, M. D. Cambridge: Riverside Press print. Pp. 11.

Kindergarten Messenger. Published by Elizabeth P. Peabody. Cambridge, 1877. Vol. I., Nos. 1 and 2. Pp. 32. Subscription, $1 a year.

Proceedings of the Boston Society of Natural History. Vol. XVIII., Part IV., April–July, 1876. Boston. Pp. 103.

Seventh Annual Report of the Commissioners of Fisheries of the State of New Jersey. Trenton: J. L. Murphy print. Pp. 42.

Geographical Surveys of the United States. Remarks on Prof. J. D. Whitney's Article in the *North American Review*, July, 1875. By Gouverneur K. Warren. Washington: Judd & Detweiler print. 1877. Pp. 28.

Local Deflections of the Plumb-Line near the Forty-ninth Parallel. By Lieutenant F. V. Greene. 1876. Pp. 13, with Diagram.

Geological Survey of Alabama, for 1876. By Eugene A. Smith, Ph. D., State Geologist. Montgomery. Pp. 100.

The Mechanical Engineer. An Address to the Graduating Class of the Stevens Institute of Technology. By R. H. Thurston, A. M., C. E. New York: D. Van Nostrand. 1875. Pp. 24.

Notes on the Ancient Glaciers of New Zealand. With Map. By I. C. Russell. 1876. Pp. 12.

Bulletin of the American Geographical Society, No. 3. Containing Annual Address of Chief-Justice Daily, delivered January 16, 1877. Pp. 70.

Science Lectures at South Kensington: Technical Chemistry. By Prof. Roscoe. London: Macmillan & Co. 1877. Pp. 46. Price, sixpence.

Dynamics, or Theoretical Mechanics. By J. T. Bottomley, M. A., F. R. S. E. New York: G. P. Putnam's Sons. Pp. 142. Price, 75 cts.

Myelitis of the Anterior Horns, or Spinal Paralysis of the Adult and Child. By E. C. Seguin, M. D. New York: G. P. Putnam's Sons. 1877. Pp. 120. Price, $1.50.

Essays on Political Economy. By Frederick Bastiat. English Translation, revised, with Notes, by David A. Wells. New York: G. P. Putnam's Sons. 1877. Pp. 291. Price, $1.25.

The Cradle of Christ: A Study of Primitive Christianity. By O. B. Frothingham. New York: G. P. Putnam's Sons. 1877. Pp. 233 Price, $1.75.

The Best Reading. Edited by Frederick B. Perkins. New York: G. P. Putnam's Sons. 1877. Pp. 343. Price, $1.25-$1.75

The Chemist's Manual; A Practical Treatise on Chemistry. By Henry A. Mott, Jr., E. M., Ph. D. New York: D. Van Nostrand. 1877. Pp. 625. Price, $6.

Washington Astronomical and Meteorological Observations, made during the Year 1874, at the United States Naval Observatory. Washington: Government Printing-Office. 1877.

POPULAR MISCELLANY.

Cotton-Culture in Egypt.—While the Khedive is taxing to the utmost the resources of his dominions in his desire to subjugate his southern neighbors, he must regard as little less than providential the reputed discovery of a new and extraordinarily-productive species of cotton-plant, the general cultivation of which in the cotton-fields of Egypt will, it is said, more than double the present annual product. According to a correspondent of the London *Times*, in the autumn of 1873, a Copt living in the upper part of the Delta, at a place called Berket-el-Sab, a station of the Cairo Railway, in the province of Menuf, noticed a plant in a cotton-field wholly different from the rest. He collected the pods, separated the seed, and planted it in secret in an isolated plot of ground. For three years he has carried on the cultivation, and now there are said to be from 800 to 1,000 pounds in the country, and the seed is sold in the public market. This seed is sold at a price twenty-five or thirty times higher than the common kind.

Comparing the product of this plant with that of the old, the *Times* correspondent remarks:

"An *ardeb* (270 pounds) of ordinary cotton-seed sows on an average eight *feddans* (acres), and produces four *cantars* (100 pounds) of cotton in seed—that is to say, the cotton with the seed inside it as it comes out of the cotton-pod. Taking this yield as the average, every ardeb planted produces 32 cantars of ginned cotton, and about 24 ardebs of seed. An ardeb of seed of the new species sows, like the other, eight feddans; but its yield is more than treble, and has even been stated at fivefold. But my most trustworthy informant only gives ten cantars per feddan, which I may add is the amount taken by one of the leading firms as the basis of their calculations as to the effect of the new plant. They add that it is difficult to say exactly what would be the ordinary yield, as all returns hitherto are the result of exceptional culture on a small scale. On this calculation of ten cantars, each ardeb of seed would produce 80 cantars of cotton in seed—that is to say, over double the amount produced by ordinary seed. At present prices each ardeb would return about £240 in seed and cotton together, instead of £96 as it does now. The new cotton, I am assured on the best authority, is of good appearance, commercially speaking, and quite equal in quality to the ordinary Egyptian cotton. The plant grows in a different manner from the ordinary cotton-plant. It grows to about the height of ten feet, has a straight, vertical stem, without branches, with very few leaves, and is thickly studded with pods. Seventy are said to have been gathered from the first plant discovered. The ordinary cotton is found on a shrub some four to five feet high, with spreading branches. Nearly a yard must be left for air, light, and growing-room between each shrub, whereas the new plant, from the absence of branches, requires only half the space."

Testimonials to Mr. Darwin.—On the occasion of his sixty-ninth birthday, Mr. Darwin was the recipient of two highly-gratifying testimonials of esteem from scientific men in Germany and in the Netherlands. From Germany came an album containing the photographs of 154 scientific men; it was inscribed, "Dem Reformator der Naturgeschichte" (To the Reformer of Natural History). The offering of the Dutch *savants* also consisted of an album, with photographs of 217 of his admirers in the Netherlands. Accompanying the latter

testimonial was a letter in which were set forth in pretty full detail the labors of Dutch naturalists before Darwin's time and since in propagating views akin to those known as "Darwinian." The first name mentioned in the letter is that of Dr. J. E. Doornik, who in 1816 went out to Java, and spent the remainder of his life in India. In his published works he held that the various modifications in which life was revealed in consecutive times originated from one another. Doornik had no influence on the thought of his time, however, and his theories were forgotten. In 1849 was published a Dutch translation of the "Vestiges of the Natural History of Creation." This work was coldly received by the representatives of natural science in the Netherlands, but found favor with the general public, and reached a third edition. Of the few Dutch scientific men who early recognized the importance of the theory of development two are named—F. C. Donders and P. Harting. The former in 1848 expressed the opinion that in the gradual change of form consequent upon change of circumstances may lie the cause of differences which we are wont to designate as species; and the latter in 1856 expressed similar views.

While visiting Utrecht in 1858, Sir Charles Lyell called the attention of the professors of the university to a paper by Wallace, in the *Journal of the Linnæan Society*, and announced as forthcoming a work by Darwin ("The Origin of Species") which could not fail to make some noise. Harting soon after declared himself a partisan of the development hypothesis, and in this he was followed by another professor in the same university (Utrecht), Miguel, Professor of Botany. In the mean time "The Origin of Species" had been translated into Dutch by F. C. Winkler. The Darwinian views were now enthusiastically adopted in the Netherlands, especially by the younger scientific men, under the lead of Emil Selenka, then Professor of Zoölogy at Leyden. Gröningen and Amsterdam were not tardy in following the lead of Utrecht and Leyden; in short, the Darwinian theory of development was very generally accepted throughout the Netherlands, and Dutch translations were published of "The Descent of Man" and "The Expression of the Emotions in Man and Animals," both by Dr. Hartogh Heys van Zouteveen. In his reply to this letter, Mr. Darwin expresses his "obligation for the very interesting history contained in it of the progress of opinion in the Netherlands with respect to evolution, the whole of which is quite new to me."

Ignorant Enterprise.—The black-slate beds of Pennsylvania have again and again lured sanguine coal-hunters to loss of time, labor, and money. In that State it is the black slate that plays the "will-o'-the-wisp" to the eager searcher after hidden wealth; elsewhere it is iron pyrites being mistaken for gold, or quartz for diamonds; and where natural deposits of wealth are out of the question, men dig into the ground in search of treasure supposed to have been buried by famous buccaneers or noted misers. Prof. Persifer Frazer lately told, at a meeting of the Academy of Natural Sciences, Philadelphia, the story of one of these searchers for mineral wealth. A farmer of Franklin County, Pennsylvania, had a dream, in which he became aware of the existence of a "treasure" in a certain field. On repairing to the spot he began to dig, and "at the first stroke of the spade," as he says, "black dirt was turned up, and at a short distance below the surface coal was found equal," in the opinion of persons supposed to be experts, "to the best Lykens Valley coal." To work the vein, a tunnel 330 feet long was cut at considerable cost. The "coal" was sent to Prof. Frazer for analysis; it was pronounced to be black slate, with a small percentage of carbon, and that chiefly graphite. It is one of the principal objects of a geological survey to save people from making mistakes like this of the Franklin County farmer.

Production of Near-Sightedness in Schools.—The effects of school-life, in producing near-sightedness in the pupils, have for some time been made the subject of systematic study by Dr. C. R. Agnew, of New York. In a recent address before the Medico-Legal Society, he stated the results of an investigation made in various schools of Cincinnati, New York, and Brooklyn. The number of students examined was 1,479, of

whom 630 were in Cincinnati, 549 in New York, and 300 in Brooklyn. Of the 630 Cincinnati pupils, 209 were from the district-schools, and of these 83½ per cent. had natural, or *emmetropic* eyes, while 10 per cent. were near-sighted. In the intermediate schools, 210 scholars were examined, and of these 80 per cent. were natural, and 14 per cent. near-sighted. In the normal high-schools, the eyes of 210 students were examined, and of these 78 per cent. were emmetropic, and 16 per cent. near-sighted. All this goes to show that near-sightedness is a progressive disease in the schools. The results for the other two cities teach the same lesson.

The 549 students mentioned above as examined in New York belonged to the New York College. Here, in the introductory classes, 57⅓ per cent. were found emmetropic, and 29 per cent. near-sighted. In the freshman class 42⅓ per cent. had natural eyes, and 40 per cent. were near-sighted. In the sophomore class no very material difference from what was observed in the preceding classes; but in the junior class 37 per cent. had natural eyes, and 56 per cent. were near-sighted. In the senior class 50 per cent. had normal eyes, and 37 per cent. were near-sighted. The Brooklyn students examined belonged to the Polytechnic Institute of that city. Here, in the academic department, 56 per cent. were emmetropic, and 10 per cent. near-sighted. In the collegiate department (a higher grade), 53 per cent. were emmetropic, and 28½ per cent. were near-sighted.

Astronomical Observations on the Rocky Mountains.—It is stated by Prof. Henry Draper, in the February number of the *American Journal of Science*, that, during two years when he photographed the moon every moonlight night at Hastings-on-the-Hudson, there were only three occasions when the air was still enough to give good results. Out of 1,500 lunar negatives, only one or two were really fine pictures.

Last summer, during a trip to the Rocky Mountains, he took with him a small achromatic, hoping to find more steadiness of the atmosphere at great elevations, but was disappointed. At Salt Lake City, 4,650 feet above the sea, Capella twinkled as badly, both to the naked eye and in the telescope, as he ever saw it at the sea-level.

At Fort Steele, near 7,000 feet elevation, Antares twinkled very much; and at Camp Douglas, 5,250 feet above the sea, the twinkling of several stars examined was surprisingly great.

At one point, however, he found the atmosphere without undulations, and the stars shone through it with a steady light. The central disk of Arcturus, he says, was hard and sharply defined; Antares near setting hardly twinkled at all; the moon was perfectly steady.

This point of observation was not far from Fort Steele, in the main range of the Rocky Mountains, at an elevation of 8,900 feet above the sea. Distant objects seemed near in the transparent air. The sky was not black, as he expected, but of a light blue; the moon, however, was near its full.

Another trial was made at Trout Lake, nearly 10,000 feet above the sea-level, and the air was found to be unsteady but transparent. At this point, however, intense cold, fierce winds, and heavy snow-falls, occur, making the location of an observatory here undesirable.

Dr. Draper concludes that the atmosphere in these high regions, although more transparent, is quite as tremulous as at the ocean-level at New York.

Influence of Heat on Galvanic Conductivity.—Till very recently it was held to be a law of Nature that the galvanic conductivity of all metals and metalloids is diminished by rise of temperature. It has been shown, however, that selenium is an exception to this rule, its conductivity being increased by heating. And now a further exception must be made in the case of tellurium, a body closely allied to selenium. We have already (in vol. x., p. 115) given an account of Siemens's researches on the action of light on selenium; we now present a synopsis of the results obtained by Franz Exner in his experiments with tellurium. Three bars of tellurium were prepared. Bar 1 broke before its dimensions were determined; bar 2 was 54 millimetres in length and 2.6 millimetres diameter; bar 3 was 153 millimetres in length and 3.73 millimetres diameter. Bar 1 was heated to 200°

Cent., and then slowly cooled. The resistance increased up to 90°, and thenceforward gradually decreased. In cooling, resistance steadily increased from 200° down to the room-temperature. This increase was so great that at the end of the experiment the resistance was six times what it was at the beginning, temperatures being equal. The same bar having been again heated from 20° to 200° Cent., there was no turning-point, and the resistance decreased steadily to the end, and increased continuously throughout in the cooling; but at the end the resistance was less than at the beginning.

Bar 2 behaved essentially like bar 1; the turning-point, however, was much higher, viz., 140°. With bar 3 five series of experiments were made, and with quite similar results. With the first heating there was a turning-point, which did not appear with after-heatings. At the maximum temperature, the resistance was pretty constant, while the resistances at the beginning and end of the experiments were very irregular.

Destruction of Germs at Low Temperatures.—Prof. Tyndall, in a communication to the London Royal Society, shows how heat, when discontinuously applied, though the temperature be below the boiling-point of water, effectually sterilizes organic infusions. In all such infusions, he observes, there is a period of latency preceding their clouding with visible bacteria. During this period the germs are being prepared for their emergence into the complete organism. They reach the end of this period of preparation successively, the period of latency of any germ depending on its condition as regards dryness and induration. The author's mode of proceeding is this: Before the latent period of any of the germs has been completed—say a few hours after the preparation of the infusion—he subjects it for a brief interval to a temperature which may be under that of boiling water. Such softened and vivified germs as are on the point of passing into active life are thereby killed; others not yet softened remain intact. This process he repeats well within the interval necessary for the most advanced of those others to finish their period of latency. The number of undestroyed germs is further diminished by this second heating. After a number of repetitions, which varies with the character of the germs, the infusion, however obstinate, is completely sterilized. The periods of heating need not exceed a fraction of a minute in duration. Sum them up in the case of an infusion which they have perfectly sterilized: they amount altogether to, say, five minutes. Boil another sample of the same infusion continuously for fifteen or even sixty minutes, and yet it is not sterilized, although the temperature is higher and its time of application more than tenfold that which, discontinuously applied, infallibly produces barrenness.

Extinction of a Prehistoric Race.—The extinction of the partially civilized race who once dwelt in the Rocky Mountain region was probably the result of some great geological change. The country is naturally arid, but doubtless when this nearly-forgotten people dwelt here in the numerous cities whose ruins are still to be seen the conditions of life were more favorable. The annals of this interesting race have perished with them, and the history of their downfall is now matter for conjecture. Mr. F. S. Dellenbaugh, of the Buffalo Society of Natural Sciences, describes as follows the course of events which resulted in the extinction of the Shinumos: When the change occurred, "the inhabitants, not understanding the science of irrigation, beheld their crops slowly but surely failing every year. The inevitable result was famine. By this their hardy constitutions were weakened, and the way was prepared for some great epidemic that swept away thousands, and left them in a melancholy condition. Then the epidemic was, possibly, soon followed by the appearance of the Indian, so entirely different from the Shinumo. He was ferocious, treacherous, cunning. Lying, cheating, stealing, murdering, were his pastimes. Then, it is no wonder that the Shinumo, in his emaciated condition, was compelled to retreat before the impetuous attack of such a foe. He was no warrior—no hunter. He had depended almost entirely on his knowledge of agriculture for his peaceful existence. It was impossible

for him to act on the defensive, and at the same time successfully till the soil. The Indian was constantly on the alert to surprise him. He must fall back and yield more territory to the exacting intruder. Vanquished and discouraged, he fortified himself in places extremely difficult of access; built cliff-houses; lived in caves, and finally became extinct. The divisions on the south side of the Colorado fared somewhat better, for the stupendous chasms of the river form a barrier that can only be crossed with success at several widely-separated points. Consequently, when the Indian reached this obstacle, his easy progress southward was interrupted. The crossing-points, too, which of course were well known to the Shinumos, had been strongly fortified by their soldiery, and thus a double check was presented to the invasion. The people then enjoyed comparative peace, till, in the course of their nomadic wanderings, the Indians discovered that there was an end to the cañon barrier, and were once more able to cope with their antagonists under favorable auspices. The Shinumos were again slowly driven back, and at the dawn of our knowledge of the region we find surviving only a mere handful of their kindred, in the Pueblo tribes, who were still defending their fortress-homes, as they had been for centuries."

Recent Outbreak of a Sandwich Island Volcano.—The volcano of Mauna Loa, Hawaii, was lately active for a few days, commencing on the evening of February 14th. A correspondent of the *San Francisco Chronicle* states that the outbreak was extremely sudden and violent:

"The point of activity was the old crater on the top of the mountain. When the eruption commenced, the flames suddenly burst from the mountain and formed a magnificent column of fire to the height of 16,000 feet above the summit. From the deck of the steamer Kilauea, lying at anchor at Kawaihae, five distinct columns of fire could be seen belching forth from the mountain, apparently not from the great summit crater of Mokuaweoweo, but from a smaller crater situated some miles distant from it, called Pohakuhanalei. A few days after intelligence reached Honolulu that the fire had disappeared, to the great disappointment of thousands who were preparing to start for the scene. But soon after news came that the great pyrotechnic exhibition of Nature still continued, and that the animation of the spectacle was enhanced by frequent earthquake-shocks. It is the general opinion that the stream of lava is flowing rapidly down the mountain-side toward Kahuku, in Kau. When last seen it had progressed a number of miles from the place of its first outbreak. The illumination was so brilliant that all parts of the island were lighted up. On the 24th the steamer Kilauea arrived with a party of excursionists at Kealakeakua Bay, the place where Captain Cook met his death. There they found that a submarine volcano had broken out near the entrance to the harbor the preceding night. About a mile from shore jets of red, green, and yellow fire leaped from the waters, interspersed with columns of steam and spray that glowed with innumerable rainbows, the spectacle being one of the grandest sights conceivable. In this locality the water is boiling and whirling like an immense caldron. Thousands of fishes are seen floating on the surface, ready cooked for the repast of swarms of Kanakas engaged in gathering the dainty abundance in their canoes. Large quantities of lava are also thrown up and float for some time on the surface. The matter is either buoyed by the intensely boiling water, or sustained by gases that gradually ooze from its pores. The submarine eruption is apparently from a fissure in the bottom of the sea, about a mile in length. It reaches the shore, and is traced inland between two and three miles. The flames on the water were first noticed by the natives at three o'clock on the morning of the 24th, and created much consternation. The depth of the water here was formerly from thirty to sixty fathoms; but, if the eruption continues, very likely a reef will be formed, which would render this bay one of the finest harbors on the Pacific. As far as known, no damage has yet attended the eruption."

How Science is advanced in Norway.—A correspondent of the London *Times*, *à propos* of the recently-published "Life of Thomas Edward," records an instance of liberal encouragement extended to a Norwegian naturalist. "Some years ago," says this correspondent, "there lived on the wild northwest coast of Norway a clergyman, with his wife, a large family, and a small income. He possessed two great advantages over Edward—a good education, and larger opportunities for observation. He, too, had the seeing eye, without which all opportunities are useless, and shortly it was known that science was being enriched by the hard-worked parish priest. The action of the Storthing was prompt. Though the majority of that body are poor peasants, and hold the purse-strings with a firm grip, they have the virtue of being liberal when good cause can be shown for it. They created a professorship of zoölogy in the Christiania University, endowed it with a

salary equal to £1,000 in England, and appointed the clergyman to the professorship, but without requiring either residence or teaching. How the professor went on enriching science with his discoveries, how he trained up his sons to follow in his footsteps, two of whom are now professors in the Christiania University, all this is known to scientific men, nor will they require to be told that the name of the clergyman was Sars."

Sir Wyville Thomson on the Theory of Evolution.—Sir Wyville Thomson said, in a lecture to the natural-history class at Edinburgh University, that the great stumbling-block, from the natural-history side of the question, in the way of an acceptance of the evolution hypothesis, was that any such passage from one species to another is entirely outside our experience. The horse had evidently been the horse since the earliest hieroglyphs were engraved upon Assyrian monuments and tombs; and the same held for all living creatures. There was not a shadow of evidence of one species having passed into another during the period of human record or tradition. Nor is this all. We have, in the fossil remains contained in the rocks, a sculptured record of the inhabitants of this world, running back incalculably farther than the earliest chisel-mark inscribed by man—incalculably farther than man's existence on this planet; and although we find from the record that thousands of species have passed away, and thousands have appeared, in no single case have we yet found the series of transitional forms imperceptibly gliding into one another, and uniting two clearly distinct species by a continuous bridge, which could be cited as an undoubted instance of the origin of a species. Mr. Darwin's magnificent theory of "natural selection" and "survival of the fittest" has undoubtedly shaken the veil by pointing out a path by which such an end might be attained; but it has by no means raised it. Still, even if we never found out the precise mode in which one species gave rise to another, there could be no further hesitation in accepting generally an hypothesis of evolution, and in regarding our present living races as the ultimate twigs of a great genealogical tree whose gradually coalescing branches we could trace, if our information were complete, to the dawn of geological time.

The Resources and Industries of Sudan.—At a late meeting of the Egyptian Geographical Society a paper on the Sudan was read, based on information collected by the late Munzinger Pasha. It was stated that there are few mountain-chains in the Sudan, but that granite ridges divide the region into well-defined districts, usually named after the rivers which flow through them. The country is, as a rule, fertile. The water-courses are mere torrents, which in summer are almost dry. The centres of population are few, and all the large towns are on the banks of the two Niles. Gold and copper are found, but the wealth of the country depends on agriculture and cattle-breeding. The population numbers about 5,000,000, consisting of Arabs and negroes. Industry is very much developed, and only articles of luxury need be imported. Stuffs, sword-blades, and leather of a very superior quality, are manufactured. The exports are chiefly ivory, gums, skins, etc. The people are nearly all Mohammedans, but their religion is mixed with numerous heathenish superstitions.

Extermination of the Grasshoppers.—Prof. A. S. Packard, Jr., has written to the *Tribune* a communication in which he advocates the project of affording Government aid toward the extermination of the Rocky Mountain locust. Locust years, he observes, are years of unusual drought, and seasons of drought occur every seven or eight years. In such summers the locust breeds in untold millions, and, the supply of food being short, they fly off hundreds of miles. A swarm observed by Prof. Robinson near Boulder City, Colorado, traveled a distance of about 600 miles to Eastern Kansas and Missouri. When seen at Boulder the swarm was on its way from the north, and may have come from some part of Wyoming. The general direction of the winds in July and August, along the eastern slope of the Rocky Mountains and on the Plains, coincides with the course of these swarms. If we would intelligently study the causes of the excessive increase and migrations of the locust, we must examine the meteorological features of the Western country, as-

certain the periods of drought and of undue rainfall, the average direction of the wind for the different months, in order to learn how far they correspond with the phenomena of locust-life. That there are cycles of dry and hot seasons recurring at irregular intervals, while the general average may remain nearly the same, century after century, is supported, though it may be vaguely, by observed facts. The author thinks that the remedy for locust visitations can be discovered and applied by a coöperation between the Signal Service and skilled entomologists employed by the General Government and the States most directly concerned.

NOTES.

It is proposed to occasionally issue from the Massachusetts Institute of Technology a "Circular," containing notes and queries on physical and chemical apparatus, processes, etc. It will be printed by the papyrographic process, and will be sent free to chemists and physicists, on condition that they from time to time communicate to the editors descriptions of apparatus and processes which they may have found convenient, and which are not in general use in laboratories. Applications for the "Circular" must be addressed to Chas. H. Weng, at the Institute of Technology, Boston.

A committee of the New York Medico-Legal Society, appointed to investigate the subject of "School Hygiene," recommend that the minimum age of admission to the public schools be six years; that the maximum attendance at school, for children under eight years, be three hours; that the schools be under medical supervision; and that schoolhouses should be surrounded on all sides with adequate open space, to secure light, ventilation, and play-grounds.

Since 1821 twelve ships have been abandoned in the arctic regions by exploring expeditions. Of these, but a single one, the Resolute, sent out with others under Sir Edward Belcher, in 1852, has been recovered.

There were three hundred competitors for the Boylston prize of the Medical Faculty of Harvard University for the best essay on the question of "Rest for Women." Dr. Mary Putnam-Jacobi, of New York, was the successful competitor. Her essay is said to possess extraordinary merit, and is to be published.

The medium of light-vibrations in the Torricellian vacuum is, according to Julius R. Mayer, extremely rarefied air. Air adheres to the glass and the mercury, and, on production of the vacuum, expands, and fills the space with a medium which conducts light like the ether in cosmical space.

A bronze statue of Livingstone, the missionary and explorer of Central Africa, will be erected in Glasgow during the present year.

In San Pete County, Utah, the hills abutting on Huntington Creek contain several valuable veins of coal. Seven mines have already been opened by drifts run from the faces of the hills. The coal yields a very fair quality of coke. These coal-fields appear to be of very considerable extent.

A piece of coral five inches in height, six inches in diameter at the top, and two inches at the base, was taken off a submarine cable at Port Darwin, North Australia. As the cable had been laid only four years, the coral must have grown to its present height in that time.

Prof. Huxley, in a recent lecture at the Royal Institution, on "The History of Birds," said that, as they now exist, birds constitute a perfectly well-defined group, nobody mistaking the forms included therein. But, when we turn to the geological record, the case is different. Fossil forms are found that present definitions do not embrace, indicating a wider range of structure, and the existence of types intermediate between birds and reptiles.

According to the *Gardener's Monthly*, the *Eucalyptus globulus* can hardly thrive in any of our States on the Atlantic seaboard, with the possible exception of Florida; there it is barely possible that a few Australian trees may live.

A correspondent of the *Lancet* writes that, when traveling in the upper Sikkim Himalaya, at elevations above 12,000 feet, he took whiskey in small quantities, to counteract the effects of strong exertion in a cold, rare atmosphere. The consequence was the reverse of what was expected, being drowsiness and lassitude, lasting an hour or more. Cold tea, on the contrary, was found to produce a feeling of exhilaration and capacity for renewed efforts.

In Calcutta the general death-rate of infants under one year among all classes of the population—Hindoo, Mohammedan, mixed race, and non-Asiatic—reaches the annual average of 480 per 1,000, the rate ranging from 184 among the non-Asiatics to 598 among the Mohammedans. Of every thousand Hindoo children born in 1875

there died 596 within the year, and of the Mohammedans no less than 735. Thus, a native child born in Calcutta has a chance of life considerably less than that of a person attacked by cholera.

Dr. A. McL. Hamilton recommends the use of nitro-glycerine as a medicinal agent in epilepsy. One-tenth of a drop on the tongue at once produces cerebral hyperæmia. The face is flushed, the eyes become bright, and the temporal vessels throb, and there are marked sensations of fullness. Diluted in alcohol in the proportion of 1 to 100, nitro-glycerine can be kept safely.

Some years ago a large tract of peat-bog was drained at Grangemouth, Scotland, the loose mud and moss being carried down the drains to the estuary. The consequence was, that the oyster-beds in the estuary were covered over with mud, and the bivalves entirely destroyed. "Nothing," writes Frank Buckland, "is so fatal to oysters as a mud-storm, except it be a sand-storm. The mud and sand accumulate in the oyster's delicate breathing-organs and suffocate it."

The telephone appears to be well adapted for transmitting signals in mines; indeed, according to the *Mining Review*, telephones are already employed with great advantage in many of the deep workings of this country.

From soundings made by the U. S. sloop Gettysburg, the Challenger, and the German frigate Gazelle, a writer in *Nature* infers the probable existence of a submarine ridge or plateau connecting the island of Madeira with the coast of Portugal, and the possible subaërial connection, in prehistoric times, of that island with the southwestern extremity of Europe. A similar plateau connects the Canary Islands with the African Continent.

The electric light has been under trial in English lighthouses nearly eighteen years. It was first tried at the South Foreland Lighthouse in 1858. An electric revolving light has been exhibited at the Souter Point Lighthouse, on the coast of Durham, for the last five years. The flash of this light has an intensity of about 392,000 candles. With the improved electric machines of Gramme or Siemens this enormous intensity of light could probably be increased five or six times.

Sideraphthite is the name of a new iron-alloy, composed of 65 parts iron, 23 nickel, 4 tungsten, 5 aluminum, and 5 copper. It is said to resist sulphureted hydrogen, is not attacked by vegetable acids, and only slightly by mineral acids. It is really more useful than standard silver, while it can be produced at a cost not exceeding that of german-silver. For alloys that have to be silver-plated to prevent oxidation, this material is a perfectly successful substitute.

The two islands of New Britain and New Ireland, lying east of New Guinea, have been visited by a Wesleyan missionary, Rev. George Brown, who has explored 150 miles of the coast of the former, and 100 miles of the latter. Mr. Brown also crossed the latter island and made large natural-history collections. No white man had ever been seen inland before, but no opposition was offered to the explorers. Abundant evidences of cannibalism were found, but the natives live chiefly on bananas, cocoanuts, and pork, and have large plantations.

Intelligence has been received of the death of two eminent German travelers in Africa: Dr. Edward Mohr, author of "The Victoria Falls of the Zambesi," and the Baron Dr. Hermann von Barth-Harmanting. The latter died by his own hand at São Paolo de Loanda, while suffering from an attack of fever, in the thirty-first year of his age; the former died at Malange, in the same Portuguese colony of Angola. Barth was, at the time of his death, engaged in making a botanical and geological survey of the Portuguese African possessions, under government auspices; Mohr had but recently returned to Africa, sent out by the German African Society to explore the country west of the great lakes.

Profs. C. V. Riley, Cyrus Thomas, and A. S. Packard, have been appointed United States Entomological Commissioners, with headquarters at Washington. It is understood that the main object of this commission is to thoroughly investigate the haunts and habits of the Rocky Mountain locust, and to devise means of exterminating that plague, or limiting its ravages. Prof. Riley will occupy himself especially with the whole country east of the mountains and south of latitude 48°, together with the west half of Iowa and the whole of the British possessions. Minnesota, Nebraska, Southern Dakota, and Eastern Wyoming, have been assigned to Prof. Thomas; and Montana, Idaho, Western Wyoming, and the Pacific slope, to Prof. Packard.

A remarkable appearance on the planet Saturn was observed by Prof. Hall, of the Naval Observatory, Washington, on December 7th. A bright spot suddenly appeared near the equator of the planet, spreading gradually till it resembled a band extending over 90°. The phenomenon continued to be visible for a month, but then the approach of the planet to the sun made further accurate observation impossible.

ALFRED RUSSEL WALLACE.

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ON THE EVOLUTION OF THE FAMILY.

By HERBERT SPENCER.

I.

LET us now look at the connections between types of family and social types. Do societies of different degrees of composition habitually present different forms of domestic arrangement? Are different forms of domestic arrangement associated with the militant system of organization and the industrial system of organization?

To the first of these questions, no satisfactory answer can be given. The same marital relation occurs in the simplest groups and in the most compound groups. A strict monogamy is observed by the miserable Wood Veddahs, living so widely scattered that they can scarcely be said to have reached the social state; and the wandering Bushmen, similarly low, though not debarred polygyny, are usually monogamic. Certain settled and slightly advanced tribes, too, are monogamic; as instance the New Guinea people, and as instance also the Dyaks, who have reached a stage passing from simple into compound. And then we have monogamy habitual with nations which have become vast by aggregation and reaggregation. Polyandry, again, is not restricted to societies of one order of composition. We find it in simple groups, as among the Fuegians, the Aleutians, and the Todas; and we find it in compound groups in Ceylon, in Malabar, in Thibet. Similarly with the distribution of polygyny. It is common to simple, compound, doubly-compound, and even trebly-compound societies.

One kind of connection between the type of family and the degree of social composition may, however, be alleged. Formation of compound groups, implying greater coördination and the strengthening of restraints, implies more settled arrangements, public and private.

Increasing rigidity of custom and growth of it into law, which goes along with the extending governmental organization holding larger masses together, affects the domestic relations along with the political relations; and thus renders the family arrangements, be they polyandric, polygynic, or monogamic, more definite.

Can we, then, allege special connections between the different types of family and the different social types classed as militant and industrial? None are revealed by a cursory inspection. Looking first at simple tribes, we find among the unwarlike Todas a mixed polyandry and polygyny; and among the Esquimaux, so peaceful as not even to understand the meaning of war, we find, along with monogamic unions, others that are polyandric and polygynic. At the same time, the warlike Caribs show us a certain amount of polyandry and a greater amount of polygyny. If, turning to the other extreme, we compare with one another large nations, ancient and modern, it seems that the militant character in some cases coexists with a prevalent polygyny and in other cases with a prevalent or universal monogamy. Nevertheless, we shall, on examining the facts more closely, discern general connections between the militant type and polygyny, and between the industrial type and monogamy.

But first we must recognize the truth that a predominant militancy is not so much to be measured by armies and the conquests they achieve, as by constancy of predatory activities. The contrast between the militant and the industrial is properly between a state in which life is occupied in conflict with other beings, brute and human, and a state in which life is occupied in peaceful labor—energies spent in destruction instead of energies spent in production. So conceiving militancy, we find polygyny to be its habitual accompaniment. To trace the coexistence of the two from Australians and Tasmanians on through the more developed simple societies up to the compound and doubly compound, would be tedious and is needless; for observing, as we have already done, the prevalence of polygyny in the less advanced societies, and admitting as we must their state of unceasing hostility to their neighbors, the coexistence of these traits is a corollary. That this coexistence results from causal connection is suggested by certain converse cases. Among the Dorians, a division of the New Guinea people, there is strict monogamy, with forbidding of divorce, in a primitive community comparatively unwarlike and comparatively industrial. Another instance is furnished by the Land Dyaks, who are monogamic to the extent that pologyny is an offense, and who, though given to tribal quarrels about their lands, and to the taking of heads as trophies, have such degree of industrial development that the men, instead of making war and the chase habitual occupations, do all the heavy work, and some division of trades and commercial intercourse exists. The Hill-tribes of India furnish other instances. There are the amiable Bodo and Dhimals, without military arrange-

ments, and having no weapons but their agricultural implements, who are industrially advanced to the extent that there is exchange of services, and that the men do all the out-of-door work; and they are monogamous. Similarly the monogamous Lepchas are wholly unwarlike. Such, too, is the relation of traits in certain societies of the New World distinguished from the rest by being partially or entirely industrial. Whereas most of the aborigines of North America, habitually polygynous, live solely to hunt and fight, the Iroquois had permanent villages and cultivated lands, and each of them had but one wife. More marked still is the case of the Pueblos, who, "walling out barbarism" by their ingeniously-conglomerated houses, fight only in self-defense, and when let alone engage exclusively in agricultural and other industries, and whose marital relations are strictly monogamic.

This connection of traits in the simpler societies, where not traceable directly in the inadequate descriptions of travelers, is often traceable indirectly. We have seen that there is a natural relation between constant fighting and development of chiefly power: the implication being that where, in settled tribes, the chiefly power is small, the militancy is not great. And this is the fact in those above-named communities characterized by monogamy. In Dory there are no chiefs; among the Dyaks subordination to chiefs is feeble; the head-man of each Bodo and Dhimals village has but nominal authority; the Lepcha flees from coercion; and the governor of a Pueblo town is annually elected. Conversely, we see that the polygyny which prevails in simple predatory tribes persists in aggregates of them welded together by war into small nations under established rulers, and frequently acquires in them large extensions. In Polynesia it characterizes in a marked way the warlike and tyrannically-governed Feejeeans; all through the African kingdoms there goes polygyny along with developed chieftainship, rising to great heights in Ashantee and Dahomey, where the governments are coercive in extreme degrees. The like may be said of the extinct American societies: polygyny was an attribute of dignity among the rigorously-ruled Peruvians, Mexicans, Chibchas, Nicaraguans. And the old despotisms of the East were also characterized by polygyny.

Allied with this evidence is the evidence that in a primitive predatory tribe, all the men of which are warriors, polygyny is generally diffused; but in a society compounded of such tribes, polygyny continues to characterize the militant part, while monogamy begins to characterize the industrial part. This differentiation is foreshadowed even in the primitive predatory tribes; since the least militant men fail to obtain more than one wife each. And it becomes marked when, in the growing population, there arises a division between warriors and workers.

Still more clearly shall we see the connection between militancy

and polygyny on recalling two facts named in the chapter on "Exogamy and Endogamy." By members of savage communities, captured women are habitually taken as additional wives or concubines, and the reputations of warriors are enhanced in proportion to the numbers thus obtained. As Mr. McLennan points out, certain early peoples permitted foreign wives (presumably along with other wives) to the military class, when wives from alien societies were forbidden to other classes. Even among the Hebrews the laws authorized such appropriations of women taken in war. The further direct connection is, that where loss of many men in frequent battles leaves a great surplus of women, the possession of more wives than one by each man conduces to the maintenance of population and the preservation of the society: continuance of polygyny being, under these circumstances, insured by the conflicts between such societies, which, other things equal, entail the disappearance of those not practising it. To which must be added the converse fact that, in proportion as decreasing militancy and increasing industrialness cause an approximate equalization of the sexes in numbers, there results a growing resistance to polygyny; since it cannot be practised by many of the men without leaving many of the rest wifeless, and causing an antagonism inconsistent with social stability. Hence monogamy is to a great extent compelled by that balance of the sexes which industrialism brings about.

Once more, the natural relation between polygyny and predominant militancy, and between monogamy and predominant industrialness, is shown by the fact that these two domestic forms harmonize in principle with the two associated political forms. We have seen that the militant type of social structure is based on the principle of compulsory coöperation, while the industrial type of social structure is based on the principle of voluntary coöperation. Now, it is clear that plurality of wives, whether the wives are captured in war or purchased from their fathers regardless of their own wills, implies domestic rule of the compulsory type: the husband is despot and the wives are slaves. Conversely, the establishment of monogamy where fewer women are taken in war and fewer men lost in war is accompanied by an increased value of the individual woman, who, even when purchased, is therefore likely to be better treated. And when, with further advance, some power of choice is acquired by the woman, there is an approach to that voluntary coöperation which characterizes this marital relation in its highest form. The domestic despotism which polygyny involves is congruous with the political despotism proper to predominant militancy; and the diminishing political coercion which naturally follows development of the industrial type is congruous with the diminishing domestic coercion which naturally follows the accompanying development of monogamy.

Probably the histories of European peoples will be cited in evi-

dence against this view: the allegation being that, from Greek and Roman times downward, these peoples, though militant, have been monogamic. It may, however, be replied that ancient European societies, though often engaged in wars, had large parts of their populations otherwise engaged, and had industrial systems characterized by considerable division of labor and commercial intercourse. Further, there must be remembered the fact that in Northern Europe, during and after Roman times, while warfare was constant, monogamy was not universal. Tacitus admits the occurrence of polygyny among the German chiefs. Already we have seen, too, that the Merovingian kings were polygamists. Even in the Carlovingian period we read that—

"The confidence of Conan II. was kept up by the incredible number of men-at-arms which his kingdom furnished; for you must know that here, besides that the kingdom is extensive as well, each warrior will beget fifty, since, bound by the laws neither of decency nor of religion, each has ten wives or more even."—(Ermold. Nigellus, iii., *ap. Scr. R. Fr.*, vi., 52.)

And Kœnigswarter says that "such was the persistence of legal concubinage in the customs af the people that traces of it are found at Toulouse even in the thirteenth century."

Thus considering the many factors that have coöperated in modifying marital arrangements—considering also that some societies, becoming relatively peaceful, have long retained in large measure the structures acquired during previous greater militancy, while other societies which have considerably developed their industrial structures have again become predominantly militant, causing mixtures of traits—the alleged relations are, I think, as clear as can be expected. That advance from the primitive predatory type to the highest industrial type has gone along with advance from prevalent polygny to exclusive monogamy, is unquestionable; and that decrease of militancy and increase of industrialness have been the essential cause of this change in the type of family, is shown by the fact that this change has occurred where such other supposable causes as culture, religious creed, etc., have not come into play.

The domestic relations, thus far dealt with mainly under their private aspects, have now to be dealt with under their public aspects. For, on the structure of the family, considered as a component of a society, depend various social phenomena.

The multitudinous facts grouped in foregoing chapters show that no true conception of the higher types of family, in their relations to the higher social types, can be obtained without previous study of the lower types of family in their relations to the lower social types. In this case, as in all other cases, error results when conclusions are drawn from the more complex products of evolution, in ignorance

of the simpler products from which they have been derived. Already an instance has been furnished by the interpretations of primitive religions given by the reigning school of mythologists. Possessed by the ideas which civilization has evolved, and looking back on the ideas which prevailed among the progenitors of the civilized races, they have used the more complex to interpret the less complex; and when forced to recognize the entire unlikeness between the inferred early religious ideas and the religious ideas found among the uncivilized who now exist, have assumed a fundamental difference in mode of action between the minds of the superior races and the minds of the inferior races: classing with the inferior, in pursuance of this assumption, certain ancient races to which the modern world is indebted for its present advance. Though to the teachings of so-called Turanians the Aryans and Semites owe their civilizations; though the Accadians had great cities, settled laws, advanced industries, arts in which four metals were utilized, and writing that had already reached the phonetic stage, while the Semites were still nomadic hordes; though the Egyptians had for some thousands of years lived as an elaborately-organized nation, approaching in many of its appliances to modern nations, and producing monuments that remain a wonder to mankind, while the Aryans were wandering with their herds in scattered groups about the Hindoo Koosh—yet these peoples are, in company with the lowest barbarians, cavalierly grouped as having radically inferior intelligences, because they show in an unmistakable way the genesis of religious ideas irreconcilable with that genesis which mythologists are led by their method to ascribe to the superior races.

All who accept the conclusions set forth in the first part of this work, will see in this instance the misinterpretation caused by analysis of the phenomena from above downward, instead of synthesis of them from below upward. They will see that in search of explanations we must go below the stage at which men had learned to domesticate cattle and till the ground.

I make these remarks by way of introduction to a criticism on the doctrines of Sir Henry Maine. While valuing his works, and accepting as true within limits the views he sets forth respecting the family under its developed form, and respecting the part played by it in the evolution of European nations, it is possible to dissent from his assumptions concerning the earliest social states, and from the derived conceptions.

As leading to error, Sir Henry Maine censures "the lofty contempt which a civilized people entertains for barbarous neighbors," which, he says, "has caused a remarkable negligence in observing them." But he has not himself wholly escaped from the effects of this sentiment. While valuing the evidence furnished by barbarous peoples

belonging to higher types, and while in some cases citing confirmatory evidence furnished by certain barbarous peoples of lower types, he has practically disregarded the great mass of the uncivilized, and ignored the vast array of facts they present at variance with his theory. Though criticisms have led him somewhat to qualify the sweeping generalizations set forth in his "Ancient Law;" though, in the preface to its later editions, he refers to his subsequent work on "Village Communities" as indicating some qualifications—yet the qualifications are but small, and in great measure hypothetical. He makes light of such adverse evidence as Mr. McLennan and Sir John Lubbock give, on the ground that the part of it he deems most trustworthy is supplied by Indian Hill-tribes, which have, he thinks, been led into abnormal usages by the influences invading races have subjected them to. And, though in his "Early Institutions" he goes so far as to say that "all branches of human society may or may not have been developed from joint families which arose out of an original patriarchal cell," he clearly, by this form of expression, declines to admit that in many cases they have *not* been thus developed.

He rightly blames earlier writers for not exploring a sufficiently wide area of induction. But he has himself not made the area of induction wide enough; and that substitution of hypothesis for observed fact which he ascribes to his predecessors is, as a consequence, observable in his own work. Respecting the evidence available for framing generalizations, he says:

> "The rudiments of the social state, so far as they are known to us at all, are known through testimony of three sorts—accounts by contemporary observers of civilizations less advanced than their own, the records which particular races have preserved concerning their primitive history, and ancient law."

And since, as exemplifying the "accounts by contemporary observers of civilizations less advanced than their own," he names the account Tacitus gives of the Germans, and does not name the accounts modern travelers give of uncivilized races at large, he clearly does not include as evidence the statements made by these.[1] Let me name here two instances of the way in which this limitation leads to the substitution of hypothesis for observation.

Assuming that the patriarchal state is the earliest, Sir Henry Maine says that "the implicit obedience of rude men to their parent

[1] He does, indeed, at page 17 of his "Village Communities," deliberately discredit this evidence—speaking of it as "the slippery testimony concerning savages which is gathered from travelers' tales." I am aware that, in the eyes of most, antiquity gives sacredness to testimony; and that so what were "travelers' tales" when they were written in Roman days have come, in our days, to be regarded as of higher authority than like tales written by recent or living travelers. I see, however, no reason to ascribe to Tacitus a trustworthiness which I do not ascribe to modern explorers, many of them scientifically educated—Barrow, Barth, Galton, Burton, Livingstone, Seeman, Darwin, Wallace, Humboldt, Burckhardt, and others too numerous to set down.

is doubtless a primary fact." Now, though among lower races, sons, while young, may be subordinate, from lack of ability to resist, yet that they remain subordinate when they become men cannot be asserted as a uniform, and therefore as a primary, fact. In a former paragraph it will be seen that obedience does not characterize all types of men. When we read that the Mantra "lives as if there were no other person in the world but himself;" that the Carib "is impatient under the least infringement" of his independence; that the Mapuché "brooks no command;" that the Brazilian Indian begins to display "impatience of all restraint at puberty"—we cannot conclude that filial submission is an original trait. When we find that, by many savages, parents, when they become burdensome in age, are killed or left to starve; that by some, as the Gullinomeros, "old people are treated with contumely, both men and women;" and that by other savages boys are not corrected for fear of destroying their spirit—we cannot suppose that subjection of adult sons to their fathers characterizes all types of men. When from Bancroft we learn that to the Navajos of North America, "born and bred with the idea of perfect personal freedom, all restraint is unendurable," and that among them "every father holds undisputed sway over his children until the age of puberty;" when we learn that, among some Californians, children after puberty "were subject only to the chief;" that among the Lower-Californians, "as soon as children are able to get food for themselves, they are left to their own devices;" and that among the Comanches male children "are even privileged to rebel against their parents, who are not entitled to chastise them but by consent of the tribe"—we are shown that in some races the parental and filial relation early comes to an end. So far from supposing that filial obedience is innate, and the patriarchal type a natural consequence, the evidence points rather to the inference that the two have evolved hand-in-hand under favoring conditions.

Again, referring to the way in which originally common ancestral origin was the only ground for united social action, Sir Henry Maine says:

> "Of this we may at least be certain, that all ancient societies regarded themselves as having proceeded from one original stock, and even labored under an incapacity for comprehending any reason except this for their holding together in political union. The history of political ideas begins, in fact, with the assumption that kinship in blood is the sole possible ground of community in political functions."

Now, if by "ancient societies" are meant those only of which records have come down to us, and if the "history of political ideas" is to include only the ideas of such societies, this may be true; but if we are to take account of societies more archaic than these, and to include under political ideas those of other peoples than Aryans and

Semites, it cannot be sustained. Proof has been given that political coöperation and the accompanying structures arise from the conflicts of social groups with one another. We have seen that this evolves chieftainship, which becomes established when the military activity is constant; and we have seen that, having first politically organized simple groups, this process afterward politically organizes compound groups, and again doubly-compound groups. Though it may be facilitated where "the commonwealth is a collection of persons united by a common descent from the progenitor of an original family," yet, in multitudinous cases, it takes place where no connection of this kind exists among the persons. The members of an Australian tribe which, under a temporary chief, join in battle against those of another tribe, have not a common descent, but are alien in blood. If it be said that political functions can in this case scarcely be alleged, then take the case of the Creeks of North America, whose men have various totems implying various ancestries, and whose twenty thousand people, living in seventy villages, have nevertheless evolved for themselves a government of considerable complexity. Or, still better, take the Iroquois, who, similar in their formation of tribes out of intermingled clans of different stocks, were welded by combined action in war into a league of five (afterward six) nations under a permanent republican government. Indeed, this system of kinship puts relations in political antagonism; so that, as we read in Bancroft of the Kutchins, "there can never be intertribal war without ranging fathers and sons against each other." Even apart from the results of mixed clanships, that instability, which we have seen characterized primitive relations of the sexes, negatives the belief that political coöperation everywhere originates from family coöperation. Instance the above-named Creeks, of whom, according to Schoolcraft, "a large portion of the old and middle-aged men, by frequently changing, have had many different wives, and their children, scattered around the country, are unknown to them."

Thus finding reason to suspect that Sir Henry Maine's theory of the family is not applicable to all human societies, let us proceed to consider it more closely:

He implies that, in the earliest stages, there were definite marital relations. That which he calls "the infancy of society"—"the situation in which mankind disclose themselves at the dawn of their history"—is a situation in which "'every one exercises jurisdiction over his wives and his children, and they pay no regard to one another.'" But in foregoing chapters on "The Primitive Relations of the Sexes," on "Promiscuity," and on "Polyandry," numerous facts have been given, showing that definite, coherent marital relations are preceded by indefinite, incoherent ones; and also that, among the marital relations evolving out of these, there are in many places types of family

composed not of a man with wife and children, but of a wife with men and children—such family-forms being found not alone in societies of embryonic and of infantine types, but also in considerably advanced societies.

A further assumption is that descent has always and everywhere been in the male line. That it has from the earliest recorded times of those peoples with whom Sir Henry Maine deals, must be admitted; and it may be admitted that male descent occurs also among some rude peoples of other types, as the Kukis of India, the Belooches, the New-Zealanders, the Hottentots. It is by no means the rule, however, among the uncivilized. Mr. McLennan, who has pointed out the incongruity between this assumption and a great mass of evidence, shows that in all parts of the world descent in the female line prevails; and the abundant proofs given by him I might, were it needful, enforce by many others. This system is not limited to groups so little organized that they might be set aside as preinfantine (were that permissible); nor to groups that stand on a level with the patriarchal, or so-called infantine, societies in point of organization; but it occurs in groups, or rather nations, that have evolved complex structures. Ellis says that kinship was through females in the two higher ranks of the Tahitians; and Erskine says the like of the Tongans. It was so, according to Piedrahita, with the ancient Chibchas, who had made no insignificant strides in civilization. Among the Iroquois, again, "titles, as well as property, descended in the female line, and were hereditary in the tribe; the son could never succeed to his father's title of sachem, nor inherit even his tomahawk;" and these Iroquois had advanced far beyond the infantine stage—were governed by a representative assembly of fifty sachems, had a separate military organization, a separate ecclesiastical organization, definite laws, cultivated lands individually possessed, permanent fortified villages. So, too, in Africa, succession to rank and property follows the female line among the coast-negroes, inland-negroes, Congo people, etc., who have distinct industrial systems, four and five gradations in rank, settled agricultures, considerable commerce, towns in streets. How misleading is the limited observation of societies, is shown by Marsden's remark respecting the Sumatrans of the Batta district, that "the succession to the chiefships does not go, in the first instance, to the son of the deceased, but to the nephew by a sister;" and that "the same extraordinary rule, with respect to property in general, prevails also among the Malays of that part of the island:" the rule which he thus characterizes as "extraordinary" being really, among the uncivilized and little civilized, the ordinary rule.

Again, Sir Henry Maine postulates the existence of government from the beginning—patriarchal authority over wife, children, slaves, and all who are included in the primitive social group. But those who have read preceding chapters on "The Regulating System" and

"Social Types" will scarcely need reminding that in various parts of the world we find social groups without heads, as the Fuegians, some Australians, most Esquimaux, the Arafuras, the Land Dyaks of the Upper Sarawak River; others with headships that are but occasional, as Tasmanians, some Australians, some Caribs, some Uaupés; and many others with vague and unstable headships, as the Andamanese, Abipones, Snakes, Chippewyans, Chinooks, Chippeways, some Kamtchatdales, Guiana tribes, Mandans, Coroados, New Guinea people, Tannese. Though it is true that in some of these cases the communities are of the lowest, I see no adequate reason for excluding them from our conception of "the infancy of society." And even saying nothing of these, we cannot regard as lower than infantine in their stages those communities which, like the Upper Sarawak Dyaks, the Arafuras, the New Guinea people, carry on their peaceful lives without other government than that of public opinion and custom. Moreover, as has been pointed out, what headship exists in many simple groups is not patriarchal. Such chieftainship as arose among the Tasmanians in time of war was determined by personal fitness. So, too, according to Edwards, with the Caribs, and, according to Swan, with the Creeks. Then, still further showing that political authority does not always begin with patriarchal authority, we have the Iroquois, whose system of kinship negatives the genesis of patriarchs, and who yet have developed a complex republican government; and we have the Pueblos, who, living in well-organized communities under elected governors and councils, show no signs of patriarchal rule in the past.

Another component of the doctrine is that, originally, property is held by the family as a corporate body. According to Sir Henry Maine, "one peculiarity invariably distinguishing the infancy of society" is that "men are regarded and treated not as individuals but always as members of the particular group." The man was not "regarded as himself, as a distinct individual. His individuality was swallowed up in his family." And this alleged primitive submergence of the individual affects even the absolute ruler of the group. "Though the patriarch, for we must not yet call him the paterfamilias, had rights thus extensive, it is impossible to doubt that he lay under an equal amplitude of obligations. If he governed the family it was for its behoof. If he was lord of its possessions, he held them as trustee for his children and kindred . . . the family, in fact, was a corporation; and he was its representative." Here, after expressing the doubt whether there can exist in the primitive mind ideas so abstract as those of trusteeship and representation, I go on to remark that this hypothesis involves a conception difficult to frame. For while the patriarch is said to hold his possessions "in a representative rather than a proprietary character," he is said to have unqualified dominion over children, as over slaves, extending to life

and death; which implies that though he possesses the greater right of owning subordinate individuals absolutely, he does not possess the smaller right of owning absolutely the property used by them and himself. I may add that besides being difficult to frame, this conception is not easily reconcilable with Sir Henry Maine's description of the *patria potestas* of the Romans, which he says is "our type of the primeval paternal authority," and of which he remarks that while, during its decline, the father's power over the son's *person* became nominal, his "rights over the son's *property* were always exercised without scruple." And I may also name its seeming incongruity with the fact that political rulers who have absolute powers of life and death over their subjects, are usually also regarded as in theory owners of their property: instance at the present time the kings of Dahomey, Ashantee, Congo, Cayor on the Gold Coast. Passing to the essential question, however, I find myself here at issue not with Sir Henry Maine only, but also with those writers on primitive social states who hold that all ownership is originally tribal, that family ownership comes afterward, and individual ownership last. As already implied, the evidence appears to me to show that from the beginning there has been individual ownership of all such things as could without difficulty be appropriated. True though it is that in early stages rights of property have not acquired definiteness; certain though it may be that among primitive men the moral sanction which property equitably obtained has among ourselves is lacking; obvious as we find it that possession is often established by right of the strongest—the evidence implies that in the rudest communities there is a private holding of useful movables maintained by each man to the best of his ability. A personal monopoly extends itself to such things as can readily be monopolized—a proprietorship not yet made definite by the growth of social regulations. The Timné, who, "regarding all property, including wives, as belonging to the strongest," show us in a typical way the primitive form of appropriation, also show us that this appropriation is completely personal, since they "burn with the deceased all his effects." Indeed, even apart from evidence, it seems to me an inadmissible supposition that in "the infancy of society" the egoistic savage, utterly without idea of justice or sense of responsibility, consciously held his belongings on behalf of those depending upon him.

One more element, indirectly if not directly involved in the doctrine of Sir Henry Maine, is that "the infancy of society" is characterized by the perpetual tutelage of women. While each male descendant has a capacity "to become himself the head of a new family and the root of a new set of parental powers," "a woman of course has no capacity of the kind, and no title accordingly to the liberation which it confers. There is therefore a peculiar contrivance of archaic jurisprudence for retaining her in the bondage of the family for life."

And the implication appears to be that this slavery of women, derived from the patriarchal state, and naturally accompanied by inability to hold property, has been slowly mitigated, and the right of private possession acquired, as the primitive family has decayed. But when we pass from the progenitors of the civilized races to existing uncivilized races, we meet with facts requiring us to qualify this proposition. Though in tribes of primitive men, knowing no law but that of brute force, entire subjection of women is the rule, yet there are exceptions, both in societies lower than the patriarchal in organization, and in higher societies which bear no traces of a past patriarchal state. We learn from Hodgson that among the Kocch, who are mainly governed by "juries of elders," "when a woman dies the family property goes to her daughters." Mason tells us of the Karens, whose chiefs, of little authority, are generally elective and often wanting, that "the father wills his property to his children. . . . Nothing is given to the widow, but she is entitled to the use of the property till her death." Writing of the Khasias, Lieutenant Steel says that "the house belongs to the woman; and in case of the husband dying or being separated from her, it remains her property." Among the Dyaks, whose law of inheritance is not that of primogeniture, and whose chieftainships where they exist are determined by merit, St. John tells us that as the wife does an equal share of work with her husband, "at a divorce she is entitled to half the wealth created by their mutual labors;" and Rajah Brooke writes, concerning certain Land Dyaks, that "the most powerful of the people in the place were two old ladies, who often told me that all the land and inhabitants belonged to them." North America furnishes kindred facts. Of the Aleutian-Islanders, Bancroft, in agreement with Bastian, tells us that "rich women are permitted to indulge in two husbands"—ownership of property by females being implied. Among the Nootkas, in case of divorce, there is "a strict division of property"—the wife taking both what she brought and what she has made; and similarly among the Jpokanes, "all household goods are considered the wife's property," and there is an equitable division of property on dissolution of marriage. Again, of the Iroquois, who, considerably advanced as we have seen, were shown, by their still-surviving system of descent in the female line, never to have passed through the patriarchal stage, we read that the proprietary rights of husband and wife remained distinct; and, further, that in case of separation the children went with the mother. Still more striking is the instance supplied by the peaceable, industrious, freely-governed Pueblos, whose women, otherwise occupying good positions, not only inherit property, but, in some cases, make exclusive claims to it. Africa, too, where the condition of women is in most respects low, but where descent in the female line continues, furnishes examples. Shabeeny tells us that in Timbuctoo a son's share of the father's property is double that of a daughter. Describing the cus-

toms of the people above the Yellala Falls on the Congo, Tuckey says fowls, eggs, manioc, and fruits, "seem all to belong to the women, the men never disposing of them without first consulting their wives, to whom the beads are given."

Thus there are many things at variance with the theory which sets out by assuming that "the infancy of society" is exhibited in the patriarchal group. As was implied in the chapters on the "Primitive Relations of the Sexes," on "Promiscuity," on "Polyandry," the earliest social groups were without domestic organization as they were without political organization. Instead of patriarchal cluster, at once family and rudimentary state, there was at first an aggregate of males and females without settled arrangements, and having no relations save those established by force and changed when the stronger willed.

OUR AMERICAN OWLS.

By Professor SAMUEL LOCKWOOD.

THE owls are rapacious birds, and in company with all the true birds of prey belong to the great order *Raptores*. The order branches into two large groups, known respectively as the diurnal and the nocturnal birds of prey. To the *Diurnes* belong the vultures, hawks, and eagles; to the *Nocturnes* belong the owls.

If Mrs. Malaprop cannot see why the owl is a "rapturous bird," she can admit its claim to openness of countenance. Once seen, the owl can never be mistaken; its flat, pussy face, and large, brassy cat-eyes, set square in front of the head, are so unbirdlike. It was a London holiday; a shop-woman and her daughter stood before the cage of Nocturnal Raptores at the "Zoo." Said the elder, "See these heagles!" to which the younger replied, "Them isn't heagles, they're 'awks." "If you please," interposed a servant standing near, "them isn't heagles nor 'awks, they're howls. My maister's son once kept one."

The owls are found nearly the whole world over. The books mention about two hundred species, as species are yet understood, and queer specimens are they every one. As a rule, how trim, spruce, compact, and graceful are the falcons, the typical birds of prey! How fluffy, squatty, and dowdyish is the typical owl! Whether it means little or much, it is thus with the Diurnal and the Nocturnal *Lepidoptera*. As the elder naturalist said: "If any analogy is allowable between different tribes of animals, the owls might be said to resemble moths" (the night-fliers), "and to differ from the diurnal birds of prey as these do from the butterflies" (the day-fliers). These birds

have been called "feathered cats," for the owl, cat-like, prowls at night, and steals upon its victim by a quick, fluffy, still swoop or spring. With the silent movements of a spirit, and a voice so supernatural, and with certain associations of time and place, the effect is appalling. As if burned into the brain-tissue with a hot iron, the memory of a certain night experience when but a lad is still fresh and vivid. It was a rural home; sickness had entered at "the witching-time of night." No man around, and the well must stay by the ill; then who should go for the doctor, more than a mile away? Impulsive and sympathetic, I was "the good and brave boy" to volunteer. Not until after midnight was the doctor's house reached, and he was out. Much disappointed that I must return alone, thinking to help the matter, I ventured upon that country-boy expedient known as a "short cut." So the open road was abandoned for a narrow path which led to the old graveyard, which having reached, my timidity began to increase. Cautiously I crossed the stile of the stone-wall, and just as I had entered, the clock in the old church-tower struck one! There was first a startling shock, then a prolonged horror, for the reverberations kept every fibre of my frame in a quivering thrill.

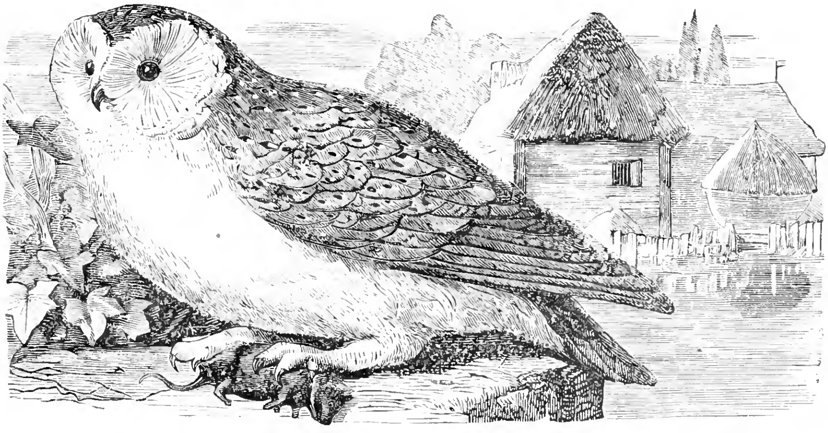

Fig. 1.—The White or Barn Owl of Europe (*Strix flammea*).

I think the moon was large, and running low, for my shadow which preceded me was frightfully long, while parallel to it, in most forbidding neighborship, lay the dark shadow of a tall Lombardy poplar, as if reflecting some huge monumental shaft. The grave of a sainted mother was near, and a certain sense of her nearness somewhat soothed the fears of that little night waif. I had now got well beyond the saddening shadow of that shaft-like tree, and the exit from the churchyard was but a few steps off, and my courage was beginning to rise, when lo! from out of that dark shaft behind me burst a savage, piercing scream, as it might be of some goblin sentry:

"Who!—who!—who-o-o-oo are you?" How that boy's heart did beat, and how he ran, almost flew, cannot be told. It was still a long way from home, but this was gained at last. He rushed into the house (the folks were up-stairs), and, without reporting to them, he immediately threw himself face downward upon the lounge, and sobbed his fright away, as little people often sensibly do. And now, if better late than never, let it be honestly confessed: that boy for years entertained a very owlish creed, built upon his own experience. He believed in a peculiar graveyard *Strix*. In fine, it may as well come out—he was a spiritualist, in the strictest, spookiest sense.

The owls are intensely carnivorous. The diminutive ones will feed largely upon insects, and some of the large kinds will eat them occasionally. But Nature has made them for prowlers, and as such we find them fond of flesh, fowl, and fish. So immense is their destruction of the smaller rodents, that they are worth millions to the agriculture of our country. They are the feathered Nimrods of the night. Even the American hare, the rabbit wrongly called, falls an easy victim. Some of the owls can fish, too. But whether hunting, fowling, or fishing, they lack the style of doing it which belongs to the falcon tribe; and when out bugging it is but a bungling business

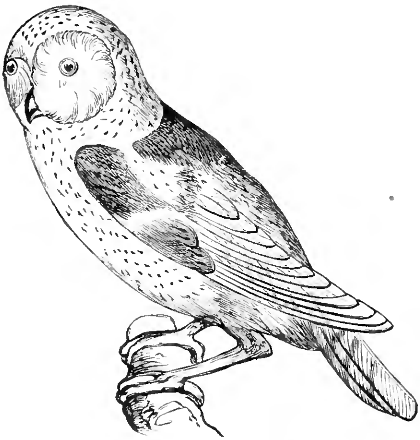

FIG. 2.—AMERICAN BARN-OWL (*Strix flammea*, Var. *Americana*).

compared with the professional *rôle* of the insectivorous birds. Their angling, too, is simply upon quiet waters. They cannot brave "the mutinous winds 'twixt the green sea and the azured vault." In common with all the *Raptores*, they catch their prey with the talons, not with the beak. In eating birds the owl prefers to tear his prey in piecemeal, but a small rodent is swallowed entire, being usually tossed into the air to adjust its position, so that it may fall head first into the bird's mouth. It disappears in one astonishing gulp. A second gulp is usually needed, as the tail is often after the first left hanging

from one side of the mouth. The indigested mass forms a roundish ball or pellet in the stomach, which the bird vomits up. These pellets or castings indicate what enormous feeders the owls are. One which I took out of the stomach of a little screech-owl was as big as a walnut, and made up of hair and bones, and had in it the skulls of six mice!

While adopting Dr. Coues's specific nomenclature, let us follow John Cassin's distribution of these birds. To aid both memory and judgment, the following scheme is offered:

FAMILY.

Strigidæ.—The Owls.

SUB-FAMILIES.

1. *Striginæ.*—The Typical Owls.
2. *Buboninæ.*—The Horned-Owls.
3. *Syrninæ.*—The Gray Owls.
4. *Atheninæ.*—The Bird-Owls.
5. *Nycteininæ.*—The Day-Owls.

1. Among the *Striginæ* we find no large owls, but here are found the typical birds of the family. Here is seen in its highest perfection of form that owlish peculiarity of the face known as the facial disk; that circle of bristle-like, radiating feathers, which helps the big round eyes to their cattish stare. The eyes, however, of the birds in this group, are not so large as are found in some species in the other groups; but the bills of the *Striginæ* are somewhat longer. Here we find the white or barn owl of the authors, which is in fact the world's traditional owl. Its portrait is given in Fig. 1, which is *Strix flammea* (Linn.), the barn-owl of Europe. This and the American barn-owl were long regarded as the same species; but Coues considers it a geographical variety, and, restoring Audubon's name, makes a sub-species of it, thus: *S. flammea*, var. *Americana* (Fig. 2). South of a certain latitude the bird is abundant on both sides of our continent, chiefly near the sea. It is sometimes found in New York and New Jersey, where it breeds in trees with the barest apology for a nest, as the eggs are laid upon the *débris* or cast-up pellets of the bird, which crumble and make a softish but filthy mess. Dr. Newberry states that he saw this bird occupying holes in the perpendicular cliffs on the shores of San Pablo Bay. Wood says the European barn-owl lives in trees and crevices of old buildings, laying its white, rough-surfaced eggs upon a soft layer of its own castings. So intensely pungent is the odor of the nest that it is with difficulty the hand can be washed free of it after meddling with the eggs. The young are described as curious little puffs of white down. The European species is often found feeding a brood of young, while it is hatching another set of eggs. The bird is often tamed, and sometimes

makes a really intelligent pet. The American species is not common in the Middle States. We saw one this spring, a gay, attractive bird, in an hotel at Tom's River, New Jersey. It fairly glowed in a warm, bright tawny hue. In reply to an inquiry, we promptly pronounced it a young barn-owl; but its owner was piqued at the idea that anybody should have seen its like before.

2. The sub-family *Buboninæ*, the eared or horned owls, are so called because of a pair of feathery, ear-like tufts, which are so set upon the head as to have earned for these birds the general name, cat-owls. Their facial disk is not quite perfect. The most famed bird of this group is the great horned-owl (*Bubo Virginianus*, Bonap.) (*see* Fig. 3). This bird has usually a white collar round the neck. It is truly

Fig. 3.—Great Horned-Owl (*Bubo Virginianus*).

a magnificent bird, of indomitable spirit and large size, being about two feet in length. It does not migrate, and is found pretty much all over North America. It breeds in winter and early spring, nesting in hollow trees and crevices of rocks, and is said to build also on some large branch, or in the crotch of a tree. Dr. Coues gives an interesting account of two unfledged ones, which he captured in Dakota, in the month of June. They were his pets for the whole summer, and traveled with him several hundred miles. For a while they had two different notes, the one of hunger or loneliness, a querulous, explosive syllable, and the other a harsh cry of anger, or remonstrance, when rudely handled. They did not begin to hoot until they were about four months old, and then only while at liberty during the night; for, says he, they became so thoroughly tame that, as their wings grew, enabling them to take short flights, I used to release them in the evening from the tether by which they were confined. They enjoyed the liberty, and eventually would stay away all night,

doubtless foraging for themselves for their natural prey, and returning to their shelter behind my tent in the morning.

The adult great horned-owl has considerable vocal ability. At one time it will startle the hearer with a barking like that of a dog; at another time it will utter sounds much like half-suppressed screams, as if of one who is getting throttled; then it will break out into a loud, wild, demoniacal yell of "Waugh O! waugh O!" startling the woods, and almost terrifying every living thing.

I was myself greatly interested in a pair of these young owls, taken from the nest early in March. Big, fluffy things they were, covered with thick, yellow down; and such eaters, nay, gormandizers is the word! It really seemed as if nothing came amiss to their appetites. The offal of chickens—heads, entrails, gizzards—all went down in quick order. One thing surprised me. As we could not at all times obtain animal food for them, my daughter thought of an experiment. She made balls, as large as hickory-nuts, of moistened meal, the outside being flavored with raw eggs. These they took down quite greedily, and, when very hungry, took the meal-balls without the flavoring. It was necessary to feed them with one's fingers. It was amusing to hear them snap their bills when annoyed or made afraid. The report thus made was pretty loud. They grew finely; but soon got killed, when off on a stray.

The little horned-owl is shown by Fig. 4. It is the *Scops asio*

Fig. 4.—The American Screech-Owl (*Scops asio*).

(Bonap.), and is variously known as the American screech-owl, the red owl, and the mottled owl. It is but ten inches long, though that is even two inches longer than its European relative. It ranges through all the Atlantic States, even up to Greenland. Nor is it driven away by the clearing off of the woods; and now more than ever it seeks to be a winter denizen of the city parks, attracted, doubtless, by the abundance of English sparrows, which afford it food. This little

screech-owl, with its staring eyes and pert, ear-like tufts, has a decidedly cattish look. In truth, it wears a grave, grimalkin cast of countenance, which, in a bird, is quite uncanny and unnatural. A mounted specimen in my parlor was an object of dread to a little girl visiting us from the city. It availed nothing to tell the child that little Motley would not hurt her, while the unbird-like little thing would stare at her so.

To the naturalist *Scops asio* has been a provoking elf. It is to be hoped that the sage-looking little fellow did not scoff behind his gravity at these learned men, or count any of them asinine whom he so misled by his eccentric freakiness in dress. Coming before a man of science at one time wearing a suit of sober frieze, again appearing in mottled gray, and anon clad gayly in tawny red, how ludicrously easy and inviting was the trick of specie-making! Well, that controversy is over now, and to write the strife down as history would be enough to make Motley bristle to his toes.

The American long-eared owl (*Otus Wilsonianus*, Less.) (Fig. 5),

Fig. 5.—American Long-eared Owl (*Otus Wilsonianus*).

is a fine bird, some fifteen inches long, and is strictly nocturnal. It often breeds in deserted nests of other large birds; but is not over-scrupulous, as it will sometimes drive away the rightful occupant of a nest, and take possession. The facial disk is perfect. Its home is temperate America, up to Hudson's Bay. "Its cry is plaintive, consisting of two or three prolonged notes repeated at intervals."

3. The *Syrninæ*, or gray owls. In this sub-family is found the largest bird of the species known in America; also the smallest specimen east of the Mississippi. Their tails are large and round. Even for owls, they have large heads, but smallish eyes, and no ear-tufts, or these almost unnoticeable. One of these is represented by Fig. 6, the barred owl (*Syrnium nebulosum*, Boie). The average size is twenty

inches. It is common South. A quaint and lively bird, its actions look like antics, for it is an oddity, even among its own folks. His portrait is that of a gay, unsuspecting fellow. He has queer ways, for an owl; he is not sedate enough. In the deep woods, and in broad daylight, when all owldom is abed, he will set up his comical half-laugh, half-cry, "Whah! whah! whah-a-a-aa!" which has in it something of the affectation of an exquisite. He is the dandy-owl—as he has been called the buffoon of the woods.

A much graver person, and the giant of American owls, is the great gray owl (*S. cinerium*, Aud.). His length is thirty inches. The cry is not unlike that of the mottled owl. The bird is common in Canada, and has been shot in New Jersey.

FIG. 6.—THE BARRED OWL (*Syrnium nebulosum*)

As representing the gray owls well, we must instance the brown or tawny owl, so called in England, although its upper parts are ashen gray (*see* Fig. 7) (*S. aluco*, Linn.). This bird is found in Great Britain, on the Continent, and in Japan. It is only some fifteen inches long, and of retiring habits, as it loves the deep, dark woods, which it will make ring with its dolorous, wolf-like cry of "Hoo! hoo! hoo!" It is an indiscriminate feeder, regaling itself on slugs, insects, small quadrupeds, birds, and fish. And it is quite a clever fisherman in its way, having been known to carry a pound-weight trout to its young. Its mode of angling is to stand stock-still, and patiently, on a protruding stone in a rippling stream, and, when an unsuspicious swimmer comes along, to invest five talons promptly, and take the venture out in fish.

In this group belongs the genus *Nyctale*, which contains the pretty little saw-whet, or Acadian owl (*Nyctale Acadiæ*, Bonap.). This is the smallest owl in the Eastern and Middle States, being but eight inches long. Its cry is said to resemble the filing or whetting of the teeth

of a saw, so that the traveler hearing it in the woods thinks he hears the man at the saw-mill sharpening the saw. It is also said that its notes resemble those of the little screech-owl of Europe, which would seem to be indicated in the *paronomasia*, or alliteration of the ancient poet:

"Est illis *strigibus* nomen; sed nominis hujus
Causa quod horrenda *stridere* nocte solent."

("The *screakers* they are called; the reason's found—
They make night hideous with their *screaking* sound.")

Nor is it all *screaking* with the saw-whet, for Audubon tells of another note, which is musical, and like the tinkling of a bell. Weight for weight, the robin would probably outdo our little Acadian owl. Nor is it only wee and winsome, it seems to be gentle also. Coues

FIG. 7.—THE TAWNY OWL OF EUROPE (*Syrnium aluco*).

records the interesting fact of one being found occupying peaceably, with a chickaree-squirrel, the same hole in an oak.

Approaching the Western seaboard, we find, under the genus *Glaucidium*, two diminutive owls, the sparrow-pygmy and the rusty pygmy-owl. These birds are not so large as the thrush.

4. The *Atheninæ*, or bird-owls. Here is found that oddly-bird-like owl, standing so un-owlishly high on its naked legs, the burrowing owl (*Athene cunicularia*, Bonap.), or *Speotyto cunicularia*, var. *Hypogæa* of Coues (Fig. 8). Very much nonsense has been written of this bird. It is said to dwell in amity with the rattlesnake and

prairie-dog, which generously shares its hole with bird and snake. The American burrowing owl is essentially a prairie-bird. It occupies, no doubt of choice, the *deserted* burrows of the *Cynomys Ludovicianus* (Baird). But if alarmed, as it would be by the presence of man, it would betake itself to the nearest hole for a refuge. In other lands the burrowing owl has no prairie-dogs to take advantage of, and in these places the owls burrow for themselves. They are diurnal prowlers, feeding chiefly on grasshoppers, crickets, and field-mice, and not improbably an occasional prairie-dog puppy. One species lives entirely

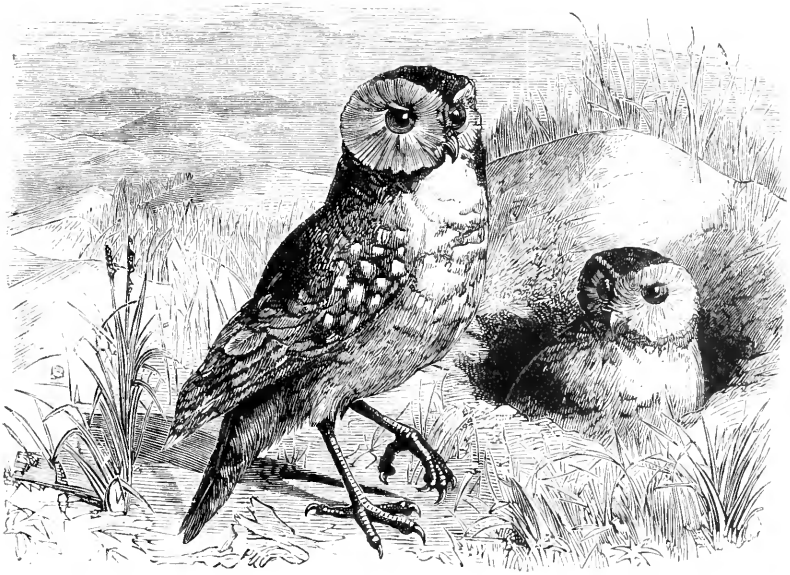

FIG. 8.—THE AMERICAN BURROWING OWL (*Athene cunicularia*).

west of the Mississippi, on both sides of the Rocky Mountains. India has a number of species, which do their own burrow-making, and are an incessantly noisy crew.

We cannot pass by that little marvel, the Liliputian of them all, named Whitney's owl (*Micrathene Whitneyi*, Coues). It was discovered by Dr. Cooper at Fort Mojave in 1860. This owl is an arboreal bird. It is partly diurnal in habit, and feeds on insects. The little thing is hardly as large as the average sparrow.

5. The *Nycteininæ*, or day-owls. This small group has but two genera, with one species in each. But here occurs the very handsomest species of the American owls. Fig. 9 shows that splendid bird known as the snowy owl, the arctic owl (*Nyctea nivea*, Gray). It has been found with a length of twenty-seven inches. Some adults are nearly all white—hence, as a show-bird, it is a favorite. We saw not long since a fine mounted specimen in a New Jersey tavern.

"What a splendid bird!" was our remark to an individual who practised at the bar. "Yes, fine enough when stuffed. But, you see, we had to do it, he got so nasty." We observed that the plumage did not indicate it. The man replied, quickly: "Oh, there was no rummage in him. We kept him tethered. All the rats and mice we ketched was given him—and the way he'd chuck 'em in wasn't slow! But, as I said, he got so nasty." We asked for an explanation. "Well, you see, he got so nasty that, just as lief as not, he'd put his talents right into your hand when you was a-feeding him. You see, the bird got so nasty that he was mean." We replied that it was the first instance of that kind of misdirected "talents" that we had ever heard of, and we agreed with him that it wasn't nice at all. "Nice?

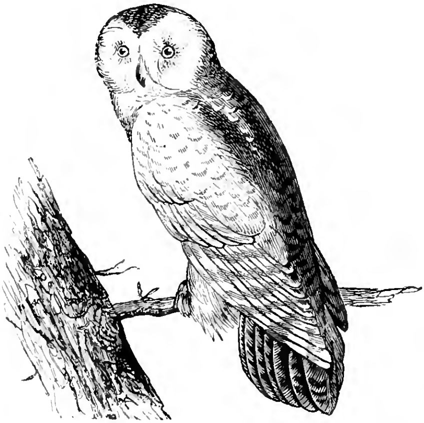

Fig. 9.—The Snowy Owl (*Nyctea nivea*).

Not much!" he rejoined. "As I said, the bird got too nasty, so we killed him, and had him stuffed." He told me the bird was caught in Warren County, and that they used to be plentiful a good many years ago.

Probably, November, 1876, will go down in ornithological history as the time of the famous southward raid of the snowy owls. Clad as they are to resist the arctic cold, and such excellent hunters—whether by day or by night—it would seem that want of food must have started these birds on their journey. Could the severe arctic winter, so disastrous to Captain Nare's expedition, have made this scarcity? It was during a pleasant autumn that these birds came upon us. There must have been some sixty shot in my own vicinity. A string of thirteen hung by a store in New York; there were many in the markets. One taxidermist in this city, it is said, had sixty left with him to be stuffed. Another in Philadelphia had about as many. As early as September flocks of ten to fifteen were seen in different places in Massachusetts. A number were shot in the city of Boston,

and others were seen perched on the churches and house-tops. For several days they were common in the city and vicinity of Portland, Maine, where not less than one hundred and fifty were shot. A worthy farmer near my home was taking his family to church. A snowy owl sat on a fence by the road, caring nothing for the passing wagon. The good man fretted, "If it wasn't Sunday, I'd bag that chap!" Probably the fellow in Washington Territory was less conscientious, for he filled two barrels with these noble birds! Almost everywhere the village taxidermists in the Eastern and Middle States had a harvest of employment. Says Ruthven Deane: "Many of the specimens were in exceedingly poor condition. Of some two hundred examined by me, nearly all were in very dark plumage, and none wore that almost spotless dress which we occasionally see."

One of these was brought by a pupil to my lecture-room in November. It was a fine fellow, but was badly hurt by the shot. It was given in charge of a young friend, who, as bird-artist, knew the worth of his prize. He kept it in his room, which served for studio and sleep. The bird had the freedom of the room, and became quite gentle, permitting itself to be fondled. One night it persisted in getting on its master's bed. This the jealousy of the hunting-dog could not stand, and every time the bird flew on the bed the dog jumped on and fought it off. At last the young man told the dog to keep quiet, when the bird came again, and, squatting by the side of its owner, kept still for the whole night. It was a great feeder. A weasel which the youth had meant to mount was stolen and devoured by the bird. Muskrats, rabbits, and birds, all went the same way; and to see him dine was a droll sight. He would open wide his great brassy optics, then insert his beak into his prey, then, shutting his eyes excruciatingly tight, would lift his head high, and gulp down whatever he had detached—all of which would be executed in the most grotesque batrachian style: for, who ever saw a frog swallow an insect but that he went it blind? Occasionally it was let out upon the snow. This was indeed a luxury, it was so like home; and the bird would swallow the snow in mouthfuls. A fine owl is this arctic bird! It will smite ducks and grouse on the wing, like a falcon; will swoop upon a hare on the ground, and dart at a fish in the shallows; and it does most of its hunting by day.

In this group occurs also that truly fine bird, the Canada or hawk owl, which is some sixteen inches long. It is often called, from its diurnal habit, the day-owl; for, though an owl, no owler is he. His work is done up clean by daylight, and it is extremely rare to hear of his being abroad at night. Looking now at Fig. 10, the Canada owl (*Surnia ulula*, Bonap.), how easily, upon a casual glance, might one mistake it for a hawk! Like some of the falcons, it will watch from the top of a tree, and will swoop thence upon its prey. It is also arboreal in its nesting, and, with its mate, is splendidly coura-

geous when the safety of person, or home, or young, is in danger. There is not much of the owlish face in our *Surnia*. The facial disk, so prominent an owlish trait, is by no means marked. Still, for all his looks and ways, this same *Surnia* is a true owl. To an unusual degree for his family, he is trim, compact, and graceful. Its favorite home is

Fig. 10.—The Hawk-Owl (*Surnia ulula*).

in the arctic regions, where "it feeds chiefly on the field-mice (*Arvicolæ*) which swarm in the sphagnous vegetation of those boreal lands; also upon small birds, grasshoppers, and other insects." In severe winters it comes southward, even to the Middle States.

The old philosophers said Nature abhorred a vacuum. Does it not appear from our owlish *résumé* that Nature has an aversion to the abrupt and disconnected? Is it not noticeable that, however natural any two great related groups of animal forms may be, they are not separated by sharp and wholly distinctive lines? There is a shading at the edges into each other. In Biblical speech, the progress of the Divine scheme is literally "little by little," and the lower group gives of the higher one, as Bishop Horseley in a different connection has said, "elegant adumbrations of sacred truth." Only when the extremes of the groups are set in contrast will the family differences best appear. Let one but look a barn-owl and a bald-eagle full in the face of each, and how clear their differentiation! But these are the typical representatives here brought face to face. Suppose we look a moment at Fig. 11, of the marsh-hawk, or harrier (*Circus cyaneus*, Linn.), and then recur to Fig. 10, of the day-owl, or *Surnia*. Now the differentiation almost fades away. How very like they are! But *Surnia* belongs to a more lowly tribe than does *Circus*. The marsh-hawk is an unmistakable falcon, and the other is assuredly an owl. But as respects this harrier, however clear as a whole the title to his

rank may be, there is a strange mix-up in the chirography of the instrument. As to wings and tail and beak and talons, he bears the insignia of a grand connection. It needs an expert to read the document, which, if it shows relation to a noble stock, shows also that Sir Harrier has very ignoble ways. His very mode of hunting is a disgrace to the name of falcon. He will course low in air like a base-born buzzard, and will dog about a small area like a hound after a rabbit, backward and forward, round and round, crossing and recrossing his course, literally scouring a patch of shrub or bush, or perhaps tall reeds or dank meadow, and harrowing the poor occupant so vulture-like, and so utterly unlike the decisiveness of action and brilliancy of dash of the genuine falcon that, with the whir of a rifle-shot, swoops from its observatory in the sky. Not one of these royal points can the marsh-hawk claim. He harries or worries his victim, and so comes honestly by his unenviable name. Although, as a high authority declares, "he is no weakling nor coward," yet he is for his belongings a mean, bullying fellow. Let us watch him from this tree.

Fig. 11.—Marsh-Hawk, or Harrier (*Circus cyaneus*).

He is harrowing a meadow-hen with her young. He has been at this worriment full fifteen minutes. Now he makes a pounce for one of the little ones. But the mother-bird proves herself a heroine on the spur, and puts him to a mean retreat. And then what hawk but he, sloven that he is, would nest upon the ground so vulture-like? There is also a tendency to fluffiness in his plumage, and a cattish noiselessness in his movements, and his queer phiz has a little of the owlish cast. Well, there is no use in denying it, it is true of him, and all these harriers, as Dr. Coues observes, "They look like owls, behave like buzzards, and nest like vultures." Hence, "the marsh-hawk combines, in a notable degree, the characters of several raptorial types, being, in particular, a link between hawks and owls."

But we have not touched bottom; and maybe these are some of His ways which are past finding out. So, having reached the deep waters, we will take that preacher's exordium to his knotty text, and make it the peroration of our discourse: "Brethren, there is mighty deep Scripture here!"

INITIATORY FORCES.

By GEORGE ILES.

LAST September, when the operations for the removal of the obstructions at Hell-Gate, in the harbor of New York, had culminated in the completion of the great labyrinth of tunnels, and the storing therein of a larger quantity of explosives than had ever been used at once before, General Newton, the chief-engineer, at the appointed moment told his little child to gently push a telegraph-key. She did so; her tiny impulse closed the circuit in many hundred galvanic cells; and these, by inflaming the metallic wires in contact with the explosives, freed in an instant the tremendous power which had been slumbering under the peaceful waters.

Perhaps in the whole realm of human achievement no more striking example of an initiatory force has ever been given than this. And if it had not had an appearance of trifling, it would doubtless have been quite possible for matters to have been so arranged that a fly imprisoned in an inverted wineglass could by the vibration of its little wings have brought two delicate electric conductors into contact—say two moistened silken filaments—and have thus pulled the trigger which, in the course of its effects, would have made Hell-Gate navigable.

In Nature and art we find abundant examples of the same kind: gigantic forces, perfectly quiescent and even useless, until some slight additional force of the proper kind or intensity precipitates the most violent changes. And this necessity for an outside initiatory force is generally found with great power to maintain action once begun. Carbon, and fuels of all kinds, are instances in point. As a rule, they are but little altered by contact with the atmosphere, even for years; but a match has only to be applied to a few shavings, and a mine of coal may be set on fire so thoroughly that it continues burning for half a century. A prairie or forest may be dried up by drought until leaves and twigs are brittle and dead, but all is calm until a chance spark from a locomotive or a tobacco-pipe starts a fire that may devastate square leagues of territory in its course.

In all cases of unstable equilibrium—and such abound in Nature—a very small impetus may produce great consequences; and this not only in amount but direction. With an avalanche perched on a moun-

tain-peak, it has often been a very slight force that has determined the path it has taken, and which of two villages miles apart was to be demolished by it. The fire-alarm system in our cities uses electricity as an initiatory motion: the hammers of the tower-bells are worked by the descent of heavy weights—wound up by manual power from time to time—and the store of energy contained in the elevated masses is instantly made available by an electric current from the central office simply freeing a detent and allowing the weight to fall. Many other recent inventions for working railway-signals, looms, etc., embody this principle. The magneto-electric machines, which are extensively employed in lighthouses and electro-plating factories, yield electricity from the mechanical motion of a steam-engine. A small permanent steel magnet is indispensable in the apparatus; it induces magnetism in soft-iron cores, and these again in others in an increasing series. The power may be gigantic, and the magnet, were it not inconvenient, might be as small as a cambric needle: yet without it neither electricity nor light can be had. A similar illustration occurs in the development of a current in a common galvanic battery: the two pieces of different metals used, as zinc and copper, when quite dry before being placed in the bath, if simply brought into contact for a moment show opposite electric polarities which, if given a mechanical expression, would be a very small amount indeed. This minute force, only to be detected by the most delicate means, is the necessary opening of the flood-gate of energy in a working battery. And when light is desired from a group of powerful cells, it is first requisite to use a small effort in bringing the poles together, and then separating them at a short distance apart. The brilliant arc of light, once across the chasm, can continue to span it; but its force, although so great, is unequal to leaping over it without help. These examples show the importance of knowing the fit initiatory forces in processes whereby one form of energy is sought to be converted into another. It is probably for lack of such knowledge that at present we waste so lamentable a quantity of heat, our commonest force, in changing it into the more desirable form of electricity, light, and mechanical motion. In exceptionally favorable circumstances, steam-engines of the best kind give but a fourth in work of the theoretical value of the heat applied, and in obtaining an electric current from an engine further loss occurs; while the production in a thermo-battery of a current from heat directly has never yet yielded as much as one-hundredth of the force employed.

A slight and well-aimed effort may not only free an immense magazine of energy, but also give it a particular direction and pilot it into one or another of two entirely new seas. Hydrogen and oxygen gases in separate receivers might remain tranquil and unchanged for ages, and it depends upon the choice of the experimenter, when he wishes to render their energy available, whether their intense chemical force

shall take the form of heat or give forth an electric current. In the former case he shall connect the receivers together by suitable tubes, apply a spark, and obtain a flame hot enough to fuse and vaporize iron or platinum. In the other case he can use Grove's gas-battery, and permit the elements to unite into water, producing an intense electric current capable of working scores of miles of telegraph. The realm of light yields us examples analogous to those given in the domains of heat and electricity. In photography it has been discovered that blue rays may begin an impression which red or yellow ones can finish, and finish only. The power of continuance is different from the power of initiation, and depends upon it for its opportunity of usefulness.

The instability of equilibrium among forces brings in an element of uncertainty, or rather incalculability, which renders prediction extremely difficult in many fields of scientific investigation. Prof. Balfour Stewart, in a most instructive essay on "Solar Physics," gives us some illustrations of this. He supposes a stratum of air in the earth's atmosphere to be very nearly saturated with aqueous vapor; that is to say, just a little above the dew-point; while at the same time it is losing heat with extreme slowness, so that if left to itself it would be a long time before moisture were deposited. Now, such a stratum is in an extremely delicate state of molecular equilibrium, and the dropping into it of a small crystal of snow would at once cause a remarkable change of state. For what would happen? The snow would cool the air around it, and thus moisture would be deposited in the form of fine mist or dew. Now, this deposited mist or dew, being a liquid, and as such much more radiant than vapor, would send its heat into empty space much more rapidly than the saturated air; and therefore it would become colder than the air around it. Thus, more air would be cooled, and more mist or dew deposited; and so on until a complete change of condition should be brought about, resulting perhaps in a shower of rain. Now, in this imaginary case, the tiniest possible flake of snow has pulled the trigger, as it were, and made the gun go off—has changed completely the whole arrangement that might have gone on for some time longer as it was, had it not been for the advent of the snow-flake. Prof. Stewart thus points out that the presence of a condensable liquid in our atmosphere adds an element of violence, and also of abruptness, amounting to incalculability, to the motions which take place. Hence meteorology must long, if not ever, remain an incomplete science, since in its problems so many variable and unstable factors occur. In the course of the same essay Prof. Stewart tells us how parallelism has been observed between three very interesting classes of phenomena, namely, the periods of maximum sun-spots, of brilliant auroral displays, and of great disturbances in the earth's magnetism. Extended observatory records show that all three coincide in their fluctuations; hence endeavors have been made to

trace them to a common source. Observations at Kew for a series of years have detected that the proximity of Mercury and Venus to the sun seems to control the size and direction of the solar spots; and therefore it appears that these planets mediately through the sun cause our auroras and magnetic storms. There is also reason to believe that the production of sun-spots diminishes by absorption the actinic rays, while the thermal ones are not noticeably affected; for to the actinic rays the chemical or ripening effect is due. Years of minimum sun-spots have been found to coincide very nearly with the good wine-years in Germany. At first sight we are startled by the supposition that a planet like Venus, which comes nearer to the earth than it ever does to the sun, should in any way be accountable for such enormous manifestations of energy as those which occur over the sun's surface. But the wonder will disappear if we bear in mind that there may be two kinds of causes or antecedents. Thus, we say that the blacksmith is the cause of the blow which his hammer strikes the anvil, and here the strength of the blow depends upon the strength of the smith. But we may likewise say that the man who pulls the trigger of a gun or cannon is the cause of the motion of the ball, and here there is no relation between the strength of the effect and that of its cause. Now, in whatever mysterious way Venus and Mercury affect the sun, we may be sure it is not after the fashion of the blacksmith: they do not deal him a violent blow producing all this enormous effect, but they rather pull the trigger, and immediately a very great change takes place. And, in passing, we are here taught how involved the relations of the parts of the universe may be. Two planets whose direct influence on the earth by their gravitation and light is quite inconsiderable, yet, by their indirect effects through their action on the sun, produce very marked and varied results on the surface of our globe. Many laboratory experiments, on a small scale, illustrate the potency of initiatory forces. A pail of water, maintained in great stillness, may be gradually chilled several degrees below the common freezing-point, when the formation of a cake of ice instantly follows from a slight shake. A clean glass vessel may be filled with water and slowly brought to a temperature in excess of the ordinary boiling-point, and a feeble shock is all that is needed for the prompt liberation of a large volume of steam. Crystallization offers similar results. A supersaturated solution of a salt may long remain in the liquid state until a crystalline fragment thrown in instantly serves as a nucleus for extensive solidification. When such a solution contains two salts, which begin to crystallize about the same temperature, when a solid fragment of each kind is thrown into the liquid, it picks out its kindred without the slightest error, and grows thereby. A new surgical method for covering a wound with skin employs as centres of growth tiny morsels of skin supplied from elsewhere. These gather together elements akin to themselves, and soon

repair the injury, otherwise very slow at healing. In some similar way it must be that a small seed of a plant selects just such ingredients from the soil as shall make it thrive and increase. On these organic powers of initiation and selection, Lucretius ponders in his great poem, and wonders how it is that different animals—the pig, dog, and fowl—eat the same food and yet make of it such diverse substance. On a seed's peculiar nature it may follow whether a field shall give its substance to maples or cabbages. Just so a volcanic island's population depends, to a large extent, on the first comers—on what human tribe first lands there, what seeds and insects are first wafted upon it, and what birds first alight on its shores. Once in possession, the process of multiplication soon renders occupancy by stray creatures of superior kinds impossible; and so we have incidentally a case where the best may not be the conquerors and survivors. Mere precedence in time is often of much account. No man shall ever have as many children as Adam. The first poets exhausted the most striking and beautiful similes in Nature, such as now may independently but uselessly occur to every cultured imagination. The limits of choice in the subjects for invention, authorship, and art, are constantly narrowed by the occupation of territory by those who have gone before. Of course, infinite additions to knowledge and achievement are possible, but many efforts suggested by the wants of the time, though quite original, are fruitless simply because they do not happen to be first.

With respect to the great effectiveness of force, when used largely or totally in initiation, Prof. Stewart thinks that intelligence depends on conditions in the organism of unstable equilibrium, and he draws a parallel between the great powers of a human mind and the marked decomposibility of its brain-substance. The particular supremacy of man in Nature is thus traced to a principle which highly characterizes his own frame, and of which he avails himself in his mastery of external Nature—delicacy of poise in construction rendering large powers obedient to slight ones.

Our subject further suggests the importance of leadership among mankind. Heroes have been so unduly praised that a reaction has set in with many thinkers, who would detract from their real value. Popular discontent, or a wide-spread spirit of enterprise, often lingers in useless agitation for want of some man a little bolder than the rest, who shall make the first onslaught on tyranny, or captain the first ship that shall set its prow toward the shores of a new world. To be sure, a hero is no more than a representative of the strong feelings of his land and time; yet, without his faith and enthusiasm, perhaps but little more than that of many of his neighbors, their desires and hopes might never have fulfillment.

Finally, our theme shows us the immense difficulties in the way of reducing some inquiries of deep interest to exact treatment. If the

problems of meteorology are of baffling intricacy, how much more so are those of history, with their elements of ignorance, of passion, and caprice—all controlling forces vastly greater than themselves! We have recently seen a few votes among hundreds decide the administration of the republic for years; and, within a decade, have beheld a single general's timidity or treachery betray a noble army into the enemy's hands, involving wide-spread ruin and deep national disgrace. And how often are our own individual lives utterly changed in purpose by a mere word, a smile, or a tear!

MESMERISM, ODYLISM, TABLE-TURNING, AND SPIRITUALISM.

By WILLIAM B. CARPENTER, C. B., M. D., LL. D., F. R. S.

II.

IT was asserted, about thirty years ago, by Baron von Reichenbach, whose researches on the chemistry of the hydrocarbons constitute the foundation of our present knowledge of paraffin and its allied products of the distillation of coal, that he had found certain "sensitive" subjects so peculiarly affected by the neighborhood of magnets or crystals as to justify the assumption of a special polar force, which he termed *Odyle*, allied to, but not identical with, magnetism; present in all material substances, though generally in a less degree than in magnets and crystals; but called into energetic activity by any kind of physical or chemical change, and therefore especially abundant in the human body. Of the existence of this odylic force, which he identified with the "animal magnetism" of Mesmer, he found what he maintained to be adequate evidence in the peculiar sensations and attractions experienced by his "sensitives" when in the neighborhood either of magnets or crystals, or of human beings specially charged with it. After a magnet had been repeatedly drawn along the arm of one of these subjects, she would feel a pricking, streaming, or shooting sensation; she would smell odors proceeding from it; or she would see a small volcano of flame issuing from its poles when gazing at them, even in broad daylight. As in the magnetic sleep light is often seen by the somnambule to issue from the operator's fingers, so the odylic light was discerned in the dark by Von Reichenbach's "sensitives," issuing not only from the hands, but from the head, eyes, and mouth, of powerful generators of this force. One individual in particular was so peculiarly sensitive, that she saw (in the dark) sparks and flames issuing from ordinary nails and hooks in a wall. It was further affirmed that certain of

these "sensitives" found their hands so powerfully attracted by magnets or crystals as to be irresistibly drawn toward them; and thus that if the attracting object were forcibly drawn away, not only the hand, but the whole body of the "sensitive" was dragged after it. Another set of facts was adduced to prove the special relation of odyle to terrestrial magnetism—namely, that many "sensitives" cannot sleep in beds which lie across the magnetic meridian; a position at right angles to it being to some quite intolerable.

Von Reichenbach's doctrine came before the British public under the authority of the late Dr. Gregory, the Professor of Chemistry in the University of Edinburgh; who went so far as to affirm that, "by a laborious and beautiful investigation, Reichenbach had demonstrated the existence of a force, influence, or imponderable fluid—whatever name be given to it—which is distinct from all the known forces, influences, or imponderable fluids, such as heat, light, electricity, magnetism, and from the attractions, such as gravitation, or chemical attraction." It at once became apparent, however, to experienced physicians conversant with the proteiform manifestations of that excitable, nervous temperament, of which I have already had to speak, that all these sensations were of the kind which the physiologist terms "subjective;" the state of the sensorium on which they immediately depend being the resultant, not of physical impressions made by external agencies upon the organs of sense, but of cerebral changes connected with the ideas with which the minds of the "sensitives" had come to be "possessed." The very fact that no manifestation of the supposed force could be obtained except through a conscious human organism should have been quite sufficient to suggest to any philosophic investigator that he had to do not with a new physical force, but with a peculiar phase of physical action, by no means unfamiliar to those who had previously studied the influence of the mind upon the body. And the fact which Von Reichenbach himself was honest enough to admit—that when a magnet was poised in a delicate balance, and the hand of a "sensitive" was placed above or beneath it, the magnet was never drawn toward the hand—ought to have convinced him that the force which attracted the "sensitive's" hand to the magnet has nothing in common with physical attractions, whose action is invariably *reciprocal;* but that it was the product of her own conviction that she *must* thus approximate it. So "possessed" was he, however, by his pseudo-scientific conception, that the true significance of this fact entirely escaped him; and although he considered that he had taken adequate precautions to exclude the conveyance of any suggestion of which his "sensitives" should be conscious, he never tried the one test which would have been the *experimentum crucis* in regard to all the supposed influences of magnets—that of using *electro-magnets*, which could be "made" and "unmade" by completing or breaking the electric circuit, with-

out any indication being given to the "sensitive" of this change of its conditions. And the same remark applies to the more recent statement of Lord Lindsay, as to Mr. Home's recognition of the position of a permanent magnet in a totally-darkened room; the value of this solitary fact, for which there are plenty of ways of accounting, never having been tested by the use of an electro-magnet, whose active or passive condition should be entirely unknown, not only to Mr. Home but to every person present.

That "sensitives" like Von Reichenbach's, in so far as they are not intentional deceivers (which many hysterical subjects are constitutionally prone to be), can feel, see, or smell, anything that they were led to believe that they *would* feel, see, or smell, was soon proved by the experimental inquiries of Mr. Braid, many of which I myself witnessed. He found that not only in hysterical girls, but in many men and women "of a highly-concentrative and imaginative turn of mind," though otherwise in ordinary health, it was sufficient to fix the attention on any particular form of *expectancy*—such as pricking, streaming, heat, cold, or other feelings, in any part of the body over which a magnet was being drawn; luminous emanations from the poles of a magnet in the dark, in some cases even in full daylight; or the attraction of a magnet or crystal held within reach of the hand—for that expectancy to be fully realized. And, conversely, the same sensations were equally produced when the subjects of them were led to *believe* that the same agency was being employed, although nothing whatever was really done; the same flames being seen when the magnet was concealed by shutting it in a box, or even when it was carried out of the room, without the knowledge of the subject; and the attraction of the magnet for the hand being entirely governed by the idea previously suggested, positive or negative results being thus obtained with either pole, as Mr. Braid might direct. "I know," he says of one of his subjects, "that this lady was incapable of trying to deceive myself or others present; but she was self-deceived and spell-bound by the predominance of a preconceived idea, and was not less surprised at the varying powers of the instrument than were others who witnessed the results." [1]

One of Mr. Braid's best "subjects" was a gentleman residing in Manchester, well known for his high intellectual culture, great general ability, and strict probity. He had such a remarkable power of voluntary abstraction as to be able at any time to induce in himself a state akin to profound reverie (corresponding to what has been since most inappropriately called the "biological"), in which he became so completely "possessed" by any idea strongly enforced upon him, that his whole state of feeling and action was dominated by it. Thus it was sufficient for him to place his hand upon the table and fix his attention upon it for half a minute, to be entirely unable to withdraw

[1] "The Power of the Mind over the Body," 1846, p. 20.

it, if assured in a determined tone that he *could not* do so. When his gaze had been steadily directed for a short time to the poles of a magnet, he could be brought to see flames issuing from them of any form or color that Mr. Braid chose to name. And when desired to place his hand upon one of the poles, and to fix his attention for a brief period upon it, the peremptory assurance that he *could not* detach it was sufficient to hold it there with such tenacity that I saw Mr. Braid drag him round the room in a way that reminded me of George Cruikshank's amusing illustration of the German fairy-story of "The Golden Goose." The attraction was dissolved by Mr. Braid's loud, cheery "All right, man," which brought the subject back to his normal condition, as suddenly as the attraction of a powerful electro-magnet for a heavy mass of iron ceases when the circuit is broken.

Similar experiments to these (which I first witnessed about thirty years ago) have been since repeated over and over again upon great numbers of persons, in whom a corresponding state can be induced by prolonged fixation of the vision on a small object held in the hand. It was in the year 1850 that a new manifestation of the supposed "occult" power first attracted public attention, through the exhibition of it by a couple of itinerant Americans, who styled themselves "professors," of a new art which they termed *Electro-Biology;* asserting that by an influence of which the secret was only known to themselves, but which was partly derived from a little disk of zinc or copper held in the hand of the "subject" and steadily gazed on by him, they could subjugate the most determined will, paralyze the strongest muscles, pervert the evidence of the senses, destroy the memory of even the most familiar things or of the most recent occurrences, induce obedience to any command, or make the individual believe himself transformed into any one else; all this, and much more, being done while he was still wide awake. They soon attracted large assemblages to witness their performances, and seldom failed to elicit some of the most remarkable phenomena from entire strangers to them, whose honesty could not be reasonably called in question. In place of a few peculiarly susceptible "subjects" not always to be met with, and open to suspicion on various grounds, those who took up this practice found in almost every circle some individuals in whom the "biological" state could be self-induced by the steady direction of their eyes to one point, at the ordinary reading-distance, for a period usually varying from about five to twenty minutes; a much shorter time generally sufficing in cases in which the practice had been frequently repeated. In this condition, the whole course of thought is directed by external suggestions, the subject's own control over it being altogether suspended. Yet he differs from the somnambulist, in being *awake;* that is, he has generally the use of all his senses, and usually, though not always, preserves a distinct recollection of all that has taken place. There is, in fact, a gradational

transition from the "biological" to the "mesmeric" state; just as there is a passage from the state of profound reverie or "day-dreaming" to that of ordinary sleep. All its strange phenomena are referable to one simple principle—the possession of the mind by a *dominant idea*, from which, however absurd it may be, the subject cannot free himself by bringing it to the test of actual experience, because the suspension of his self-directing power prevents him from correcting his ideational state by comparing it with external realities; this suspension being often as complete as it is in dreaming, so that, though the senses are awake, they cannot be turned to account. But it may exist in regard to one sense only, the impressions made on others being truly represented to the mind. Thus I have seen instances in which a "biologized" subject could be made to believe himself to be *tasting* anything which the operator might assure him that he *would* taste—such as milk, coffee, wine, or porter—when drinking a glass of pure water, though he was instantly disabused by *looking* at the liquid; while another would *see* milk or coffee, wine or porter, as he was directed, but would instantly set himself right when he *tasted* the liquid. Nothing can be more amusing than to experiment upon a subject who has no misgivings of this kind, but whose perceptions are altogether under the direction of the ideas impressed upon him. He may be made to exhibit all the manifestations of delight which would be called forth by the viands or liquors of which he may be most fond, and these may be turned in a moment into expressions of the strongest disgust, by simply giving the word which shall (ideally) change it into something he detests. Or if, when he believes himself to be drinking a cup of tea or coffee, he be made to believe that it is very hot, nothing will induce him to take more than a sip at a time; yet a moment afterward he will be ready to swallow the whole in gulps, if assured that the liquid is quite cool. Tell him, again, that his seat is growing hot under him, and that he will not be able to remain long upon it, and he will fidget uneasily for some time, and at last start up with all the indications of having found the heat no longer bearable. While he is firmly grasping a stick in his hand, let him be assured that it will burn him if he continue to hold it, or that it is becoming so heavy that he can no longer sustain it, and he will presently drop it with gestures conformable in each case to the idea.

It may, of course, be said that what I have presented to you as real phenomena are only simulated; and as there would be nothing difficult in such simulation, the supposition is of course admissible. But they are so perfectly conformable to the known principles of Mental action, that there is no justification for the suspicion of deceit, when they are presented by persons in whose good faith we have reasonable grounds of confidence. For every one must be conscious of occasional mistakes as to what he supposes himself to have seen or

heard, which he can trace to a previous expectancy. Of this I can give you a very striking illustration in a case narrated by Dr. Tuke. A lady, whose mind had been a good deal occupied on the subject of drinking-fountains, was walking from Penrhyn to Falmouth, and thought she saw in the road a newly-erected fountain, with the inscription, "If any man thirst, let him come hither and drink." Some time afterward, on mentioning the fact with pleasure to the daughters of a gentleman whom she supposed to have erected it, she was greatly surprised to learn from them that no such drinking-fountain existed; and, on subsequently repairing to the spot, she found nothing but a few stones, which constituted the foundation on which her expectant imagination had built an ideal superstructure.

The same may be said with regard to the control exercised over the muscular movements of the biologized "subject," by the persuasion that he *must* or that he *cannot* perform a particular action. His hands being placed in contact with one another, he is assured that he cannot separate them, and they remain as if firmly glued together, in spite of all his apparent efforts to draw them apart. Or, a hand being held up before him, he is assured that he cannot succeed in striking it; and not only does all his power seem inadequate to the performance of this simple action, but it actually is so as long as he remains convinced of its entire impossibility. So I have seen a strong man chained down to his chair, prevented from stepping over a stick on the floor, or obliged to remain almost doubled upon himself in a stooping position, by the assurance that he *could not* move. On the other hand, an extraordinary power may be called forth in any set of muscles—as in hypnotized subjects—by the assurance that the action to be performed by them may be executed with the greatest facility. This, again, is quite conformable to ordinary experience; the assurance that we *can* perform some feat of strength or dexterity nerving us to the effort; while our power is weakened by our own doubts of success, still more by the unfavorable impression produced by a confident prediction of failure. It is only needed for the mind to become completely "possessed" by the one or the other conviction for it to produce the bodily results of this kind which I have over and over again witnessed.

Now the phenomena of the "biological" condition seem to me of peculiar significance, in relation to a large class of those which are claimed as manifestations of a supposed "spiritual" agency. When a number of persons of that "concentrative and imaginative turn of mind" which predisposes them to the "biological" condition sit for a couple of hours (especially if in the dark) with the expectation of some extraordinary occurrence—such as the rising and floating in the air, either of the human body, or of chairs or tables, without any physical agency; the crawling of live lobsters over their persons; the contact of the hands, the sound of the voices, or the visible luminous

shapes,[1] of their departed friends—it is perfectly conformable to scientific probability that they should pass more or less completely (like Reichenbach's "sensitives") into a state which is neither waking nor sleeping, but between the two, in which they see, hear, or feel, by touch, anything they have been led to expect will present itself. And the accordance of their testimony, in regard to such occurrences, is only such as is produced by the community of the dominant idea with which they are all "possessed," a community of which history furnishes any amount of strangely-varied examples. And thus it becomes obvious that the testimony of a single cool-headed skeptic, who asserts that nothing extraordinary has really occurred, should be accepted as more trustworthy than that of any number of believers, who have, as it were, created the sensorial result by their anticipation of it.

I have now to show you that the like expectancy can also produce *movements* of various kinds, through the instrumentality of the nervo-muscular apparatus, without the least consciousness on the part of its subject of his being himself the instrument of their performance; a physiological fact which is the key to the whole mystery of table-turning and table-talking. I very well remember the prevalence in my schoolboy days of a belief that, when a ring, a button, or any other small body, suspended by a string over the end of the finger, was brought near the outside or inside of a glass tumbler, it would strike the hour of the day against its surface; and the experiment certainly succeeded in the hands of several of my schoolfellows, who tried it in all good faith, getting up in the middle of the night to test it, in entire ignorance, as they declared, of the real time. But, as was pointed out by M. Chevreul, who investigated this subject in a truly scientific spirit more than forty years ago,[2] it is impossible by any voluntary effort to keep the hand absolutely still for a length of time in the position required; an involuntary tremulousness is always observable in the suspended body, and if the attention be fixed on it with the expectation that its vibrations will take a definite direction, they are very likely to do so. But their persistence in that direction is found to last only so long as they are guided by the sight of the operator, at once and entirely losing their constancy if he closes or turns away his eyes. Thus it became obvious that, in the striking of the hour, the influence which determines the number of strokes is really the knowledge or suspicion present to the *mind* of the operator, which involuntarily and unconsciously directs the action of his muscles; and the same *rationale* was applied by M. Chevreul to other cases in which this *pendule explorateur* (the use of which can be traced

[1] I put aside the question of fraud, to which recourse has doubtless often been had for the production of these phenomena; being satisfied that they are often genuinely "subjective."

[2] *See* his letters to M. Ampère, in the *Revue des Deux Mondes*, May, 1833.

back to a very remote date) has been appealed to for answers to questions of very diverse character.

When, however, "Odyle" came to the front, and the world of curious but unscientific inquirers was again "possessed" by the idea of an unknown and mysterious agency, capable of manifesting itself in an unlimited variety of ways, the *pendule explorateur* was brought into vogue, under the name of *odometer*, by Dr. Herbert Mayo,[1] who investigated its action with a great show of scientific precision; starting, however with the foregone conclusion that its oscillations were directed by the hypothetical "odyle," and altogether ignoring the mental participation of the operator, whom he supposed to be as passive as a thermometer or a balance. By a series of elaborate experiments, he convinced himself that the direction and extent of the oscillations could be altered, either by a change in the nature of the substances placed beneath the "odometer," or by the contact of the hand of a person of the opposite sex, or even of the experimenter's other hand, with that from which it was suspended. And he gradually reduced his result to a series of definite laws, which he regarded as having the same constancy as those of physics or chemistry. Unfortunately, however, other experimenters, who worked out the inquiry with similar perseverance and good faith, arrived at such different results, that it soon came to be obvious that what astronomical observers call the "personal equation" of the individual has a very large share in determining them. A very intelligent medical friend of my own, then residing abroad, wrote me long letters full of the detailed results of his own inquiries, on which he was anxious for my opinion. My reply was simply: "Shut your eyes, or turn them away, and let some one else watch the oscillations under the conditions you have specified, and record their results; you will find, if I do not mistake, that they will then show an entire *want* of the constancy you have hitherto observed." His next letter informed me that such proved to be the case; so that he had come entirely to agree with me as to the dependence of the previous uniformity of his results on his own expectancy.

A curious variation of the "odometer" was introduced by Mr. Rutter, the manager of the gas-works at Brighton, under the name of "magnetometer," which was simply a gallows-shaped frame, mounted on a solid base, having a metallic ball suspended from its free extremity. When the finger was kept for a short time in contact with this frame, the ball began to oscillate, usually in some definite direction, changing that direction with any change of circumstances, after the manner of Dr. Mayo's "odometer." To many persons, as to Mr. Rutter himself, it appeared impossible that these oscillations could have their origin in any movement of the operator; but every one who knows how difficult it is to prevent vibrations in the sup-

[1] "The Truths contained in Popular Superstitions," 1851.

porting framework of a microscope or telescope, and who recognizes that the construction of the "magnetometer" is exactly such as will enable the smallest amount of imparted motion to produce the greatest sensible effect, will be prepared to expect that the oscillations of the suspended ball are as much maintained and guided by the expectancy of the operator as they are when it is hung directly from his own finger. Experiment soon proved this to be the case: for it was found that the constancy of the vibrations entirely depended upon the operator's watching their direction, either by his own eyes or by those of some one else; and, further, that when such a change was made *without his knowledge* in the conditions of the experiment, as *ought*, theoretically, to alter the direction of the oscillations, no such alteration took place.

A very amusing *exposé* of the mystery of the "magnetometer" resulted from its application by Dr. Madden, an homœopathic physician at Brighton, to test the virtues of his "globules," as to which he had, of course, some preformed conclusions of his own. The results of his first experiments entirely corresponded with his ideas of what they ought to be; for when a globule of one medicine was taken into his disengaged hand, the suspended ball oscillated longitudinally; and when this globule was changed for another of opposite virtues, the direction of the oscillations became transverse. Another homœopathic physician, however, was going through a similar course of experiments; and his results, while conformable to his own notions of the virtues of the globules, were by no means accordant with those of Dr. Madden. The latter was thus led to reinvestigate the matter with a precaution he had omitted in the first instance; namely, that the globules should be placed in his hand by another person, without any hint being given him of their nature. From the moment he began to work upon this plan, the whole aspect of the subject was changed; globules that produced longitudinal oscillations at one time gave transverse at another, while globules of the most opposite remedial virtues gave no sign of difference. And thus he was soon led to the conviction, which he avowed with a candor very creditable to him, that the system he had built up had no better foundation than his own anticipation of what the results of each experiment should be; that anticipation expressing itself unconsciously in involuntary and imperceptible movements of his finger, which communicated a rhythmical vibration to the framework when the oscillations of the ball suspended from it were watched.

Thus, by the investigations of scientific experts who were alive to the sources of fallacy which the introduction of the *human* element always brings into play, the hypothesis of odylic force was proved to be completely baseless; the phenomena which were supposed to indicate its existence being traceable to the physiological conditions of the human organisms through whose instrumentality they were mani-

fested. The principle that the state of "expectant attention" is capable of giving rise either to sensations or to involuntary movements, according to the nature of the expectancy, had been previously recognized in physiological science, and was not invented for the occasion; but the phenomena I have been describing to you are among its most "pregnant instances."

The same principle furnishes what I believe to be the true scientific explanation of the supposed mystery of the divining-rod, often used where water is scarce for the discovery of springs, and in mining-disstricts for the detection of metallic veins. This rod is a forked twig shaped like the letter Y, hazel being usually preferred; and the diviner walks over the ground to be explored, firmly grasping its two prongs with his hands, in such a position that its stem points forward. After a time the end of the stem points downward, often, it is said, with a sort of writhing or struggling motion, especially when the fork is tightly grasped; and sometimes it even turns backward, so as to point toward instead of away from the body of the diviner. Now, there is a very large body of apparently reliable testimony, that when the ground has been opened in situations thus indicated, either water-springs or metallic veins have been found beneath; and it is quite certain that the existence of such a power is a matter of unquestioning faith on the part of large numbers of intelligent persons who have witnessed what they believe to be its genuine manifestations.[1] This subject, however, was carefully inquired into more than forty years ago by MM. Chevreul and Biot; and their experimental conclusions anticipated those to which I was myself led in ignorance of them by physiological reasoning. They found that the forked twig cannot be firmly grasped for a quarter of an hour or more in the regulation position, without the induction of a state of muscular tension, which at last discharges itself in movement; and this acts on the prongs of the fork in such a manner as to cause its stem to point, either upward, downward, or to one side. The occasion of this discharge and the direction of the movement are greatly influenced, like the oscillations of bodies suspended from the finger, by *expectancy* on the part of the operator; so that if he has any suspicion or surmise as to the "whereabouts" of the object of his search, an involuntary and unconscious action of his muscles causes the point of the rod to dip over it.

Again, since not one individual in forty, in the localities in which the virtues of the divining-rod are still held as an article of faith, is found to obtain any results from its use, it becomes obvious that its movements must be due, not to any physical agency directly affecting the rod, but to some influence exerted through its holder. And that this influence is his *expectation* of the result may, I think, be pretty confidently affirmed. For it has been clearly shown, by careful and

[1] I have lately received a pamphlet from an engineer in the United States, giving most circumstantial details of success thus obtained within his own experience.

repeated experiments, that, while the rod dips when the "diviner" knows or believes he is over a water-spring or a metallic vein, the results are uncertain, contradictory, or simply negative, when he is blindfolded, so as not to be aware precisely where he is. The following is a striking case of this kind that has been lately brought to my knowledge:

"A friend of mine," says Dr. Beard,[1] "an aged clergyman, of thorough integrity and fairness, has for many years—the larger part of his natural life, I believe—enjoyed the reputation of being especially skilled in the finding of places to dig wells, by means of a divining-rod of witch-hazel, or the fresh branches of apple or other trees. His fame has spread far, and the accounts that are given by him and of him are, to those who think human testimony is worth anything, overwhelmingly convincing. He consented to allow me to experiment with him. I found that only a few moments were required to prove that his fancied gift was a delusion, and could be explained wholly by unconscious muscular motion, the result of expectancy and coincidence. In his own yard there was known to be a stream of water running through a small pipe a few feet below the surface. Marching over and near this, the rod continually pointed strongly downward, and several times turned clear over. These places I marked, blindfolded him, marched him about until he knew not where he was, and took him over the same ground over and over again; and, although the rod went down a number of times, *it did not once point to or near the places previously indicated.*"

I very well remember having heard, some thirty-five years ago, from Mr. Dilke (the grandfather of the present Sir Charles), of an experiment of this kind which he had himself made upon a young Portuguese, who had come to him with a letter of introduction, describing the bearer of it as possessing a most remarkable power of finding, by means of the divining-rod, metals concealed from view. Mr. Dilke's family being at a summer residence in the country, his plate had all been sent to his chambers in the Adelphi, where he was visited by the Portuguese youth; to whom he said, "Go about the room with your rod, and try if you can find any mass of metal." The youth did so; and his rod dipped over a large standing desk, in which Mr. Dilke's plate had been temporarily lodged. Seeing, however, that there were circumstances which might reasonably suggest this guess, Mr. Dilke asked the youth if he was willing to allow his divining power to be tested under conditions which should exclude all such suggestion; and, having received a ready assent, he took his measures accordingly. Taking his plate-box down to his country residence, he secretly buried it just beneath the soil in a newly-ploughed field; selecting a spot which he could identify by cross-bearings of conspicuous trees, and getting a plough drawn again over its surface, so as to make this correspond precisely with that of the rest of the field. The young diviner was then summoned from Lon-

[1] *Review of Medicine and Pharmacy* (New York), September, 1875.

don, and challenged to find beneath the soil of this field the very same plate which he had previously detected in Mr. Dilke's desk at the Adelphi; but, having nothing watever to guide him even to a guess, he was completely at fault. Mr. Dilke's impression was that he was not an impostor, but a sincere believer in his own power, as the "dowsers" of mining-districts seem unquestionably to be. The test of blindfolding the diviner, and then leading him about in different directions, so as to put him completely at fault in regard to his locality, is one that can be very readily applied, when the diviner is acting in good faith; but, as I shall show you in the next lecture, it requires very special precautions to blindfold a person who is determined to see; and, in some of the cases which seem to have stood this test, it seems not improbable that vision was not altogether precluded.

An additional reason for attributing the action of the divining-rod to the muscular movements called forth by a state of expectancy (perhaps not always consciously entertained) on the part of the performer seems to me to be furnished by the diversity of the powers that have been attributed to it; such as that of identifying murderers and indicating the direction of their flight, discovering the lost boundaries of lands, detecting the birthplace and parentage of foundlings, etc. The older writers do not in the least call in question the reality of the powers of the hazel-fork, but learnedly discuss whether they are due to natural or to diabolic agency. When in the last century the phenomena of electricity and magnetism became objects of scientific study, but had not yet been comprehended under the grasp of law, it was natural that those of the divining-rod should be referred to agencies so convenient, which seemed ready to account for anything otherwise unaccountable. But, since physicists and physiologists have come to agree that the moving power is furnished by nothing else than the muscles of the diviner, the only question that remains is, What calls forth its exercise? And the conclusive evidence I have given you that the definite oscillations of suspended bodies depend on involuntary movements unconsciously determined by states of *expectancy*, clearly points to the conclusion that we have in the supposed mystery of the divining-rod only another case of the same kind. It is well known that persons who are conversant with the geological structure of a district are often able to indicate with considerable certainty in what spot, and at what depth, water will be found; and men of less scientific knowledge, but of considerable practical experience, frequently arrive at a true conclusion on this point, without being able to assign reasons for their opinions. Exactly the same may be said in regard to the mineral structure of a mining-district; the course of a metallic vein being often correctly indicated by the shrewd guess of an observant workman, where the scientific reasoning of the mining-engineer altogether fails. It is an

experience we are continually encountering in other walks of life, that particular persons are guided, some apparently by an original and others by an acquired intuition, to conclusions for which they can give no adequate reasons, but which subsequent events prove to have been correct; and I look upon the divining-rod in its various applications as only a peculiar method of giving expression to results worked out by an automatic process of this kind, even before they rise to distinct mental consciousness. Various other methods of divination that seem to be practised in perfectly good faith—such, for example, as the Bible and key test, used for the discovery of stolen property—are probably to be attributed to the same agency; the cerebral traces of past occurrences supplying materials for the automatic evolution of a result (as they unquestionably do in dreams) when the occurrences themselves have been forgotten.

Many of the cases of so-called thought-reading are clearly of the same kind; the communication being made by unconscious muscular action on the part of one person, and automatically interpreted by the other—as in the following instance: Several persons being assembled, one of them leaves the room, and during his[1] absence some object is hidden. On the absentee's reëntrance, two persons, who know the hiding-place, stand one on either side of him, and establish some personal contact with him; one method being for each to place a finger on his shoulder, and another for each to place a hand on his body, one on the front and the other on the back. He walks about the room between the two, and generally succeeds before long in finding the hidden object; being led toward it (as careful observation and experiment have fully proved) by the involuntary muscular action of his unconscious guides, one or the other of them pressing more heavily when the object is on his side, and the finder as involuntarily turning toward that side.

These and other curious results of recent inquiry, while strictly conformable to physiological principles, greatly extend our knowledge of the modes in which states of mind express themselves unconsciously and involuntarily in muscular action; and I dwell on them the more because they seem to me to afford the key (as I shall explain in my next lecture) to some of these phenomena of spiritualistic divination, which have been most perplexing to many who have come in contact with them, without being disposed to accept the spiritualistic interpretation of them.—*Fraser's Magazine.*

[1] The experiment succeeds equally well, or perhaps better, with ladies.

ON THE DISTRIBUTION OF STANDARD TIME IN THE UNITED STATES.

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FOR the ordinary purposes of life in a state of society which is not yet complex, a very simple system of recording the lapse of time is sufficient. Sunrise and sunset are local phenomena, which from the earliest times forced themselves upon the attention of every one, and which throughout the early centuries sufficed for the division of time. A further division of the duration of the day (as defined by the continuance of sunlight) was obtained by noting the time of *noon*, and there is no historic period known in which the method of obtaining a rough approximation to this instant by means of the shadow of a vertical rod or pillar was not understood. Probably the observation of such a *gnomon* or *style* constituted the first step in *astronomy of precision*, as distinguished from that astronomy in which numbers do not play the most important part. The instant so determined is technically called the instant of *apparent noon* at any place, and it marks the moment when the sun is highest above the horizon and on the meridian.[1]

Until within a hundred years this apparent time, that is the time marked by the angular distance of the sun from the meridian of any place, was the system universally adopted. A watch should mark $12^h\ 0^m\ 0^s$ when the sun was highest. But the lengths of apparent solar days, or the time elapsed between two successive apparent noons, are not equal at different parts of the year, since the true sun does not move in a plane perpendicular to the earth's rotation axis (the *equator*), but in the *ecliptic*, a plane greatly inclined to the *equator*, and since the sun's motion in the ecliptic is not uniform. Hence arises an inequality in these apparent solar days, and a capital advance was made by the adoption of *mean solar time*, which is now universal. Local *mean noon* is the time when an imaginary sun supposed to move uniformly in the equator is on the meridian of any place, as New York, and a mean solar day is the interval between two successive mean noons. This is divided into twenty-four hours, and these again into minutes and seconds, and the length of these units is practically invariable.

The time of mean noon differs from the instant of apparent noon no less than sixteen minutes at certain times in the year, being some-

[1] Rigorously, the sun may not have its *maximum* altitude on the meridian, but its maximum altitude can never differ from its meridian altitude by more than half a second of arc.

times in advance of it, and sometimes later; so that the moment when the sun was highest at a certain place does not mark a determinate instant unless the day of the year is also given.

It is necessary to remember this, and to insist somewhat upon it, as the idea that the local noon as determined by clocks and watches is a sort of naturally determined epoch is widely spread, while the fact is that it is an artificial epoch, which can only be fixed by a somewhat difficult astronomical observation and a subsequent computation. The farm-laborer who eats his dinner in the field at the time that shadows cast by the sun point north and south is the victim of his own ignorance, as he sometimes anticipates the noon of watches and clocks by more than a quarter of an hour, and is sometimes equally in retard. The improvement of the balance-watch upon the *clepsydra* or the hour-glass and other early time-keepers caused the change to be made from apparent to mean time, and the increasing requirements of a complex civilization demand more and more attention to the keeping of accurate standard time. One of the most important functions of observatories is the determination of such a standard of time, and if this were their sole function the expense of maintaining them would be fully repaid.

If the standard time is important to the man of business in making his appointments and regulating his affairs, to the traveler in providing railways with a correct time by which to govern the movements of trains, and in general to every citizen in his daily occupations on land, it is vital to the successful and safe navigation of the ocean. Every ship that sails for a foreign port must before her departure know the *correction* of her chronometers to Greenwich time (that is, the number of seconds they are *fast* or *slow* on that time), and besides this their *rate* (or the number of seconds they daily gain or lose). Provided with good chronometers and with these data well determined, a ship sails from her port with the power of determining on any day her position on the earth's surface.

A simple observation of the altitude of the sun at noon gives, by a short computation, her latitude, and a determination of the angular distance of the sun east or west of her meridian gives the local time. The difference of the local time of the ship and the Greenwich time, as shown by her chronometers, gives her longitude. Latitude and longitude being known, her place on the chart can be put down with but little uncertainty. This is daily done, if possible, on every one of the ships sailing out of New York City, and on the skill of her officers, the goodness of her chronometers, and the accuracy of their rates, depends the safety of her passengers and cargo. To all men of business, then, in their appointments and affairs on shore and in their commercial ventures by sea, the fact that a standard time is easily attainable and perfectly correct is of no slight importance. To travelers, whether by sea or land, it is truly a matter of life and

death. The watches of railway employés are usually set by one clock, but a difference of one or two minutes on a crowded road may bring about the most fatal results, as the reports of the various railway commissions will show. If a ship leaves New York supposing her chronometer which is regulated to Greenwich time to be losing two seconds a day, while it is really losing six, every day she is really about a mile farther west than her reckoning shows her to be, and in a voyage of a month she will suppose herself to be too far west by thirty miles. Such a result may be attended with the most disastrous consequences, and that it does not oftener so result is due to the skill and watchfulness of sea-captains, a class of men whose vigilance and faithfulness are too little appreciated.

That such accidents do occur is brought constantly before us, in the reports of marine disasters as given in the newspapers and elsewhere, and every year a large volume is published by the English Government—the "Report of Wrecks and Casualties," etc.—in which the details are given. A simple inspection of the wreck-chart appended to this bulky annual volume, where every vessel wrecked during the year has the place of her loss indicated by a dot on the map, shows how frequent such losses are. I know of no simpler way of presenting the risks run, when the actual wreck is not incurred, than by giving the following table from the report for 1863 of Mr. Hartnup, Director of the Observatory of Liverpool, an observatory founded especially for the care of the chronometers of merchant-ships.

The work of this observatory has been continued for many years, and a large mass of statistics concerning the running of the chronometers of ships sailing out of Liverpool has been accumulated and partially discussed.

In the earlier history of the observatory, its attention was confined to the *rating* of chronometers, and, when any chronometer was sent to a ship with a given *correction* and *rate*, a record was kept of the fact.

On the return of the chronometer to Liverpool every effort was made to find the *correction* and *rate* which were given at the foreign port to which the ship was bound, and in this way a vast amount of statistical information concerning the running of the chronometers of merchant-ships out of Liverpool was accumulated.

In the following table, which summarizes these statistics, the *first* horizontal column contains the length of the voyage in months; the *second*, the average error of longitude in geographical miles on the equator, deduced from the means of 1,700 chronometers; and the remaining columns show the average error of the best ten instruments in one hundred, of the second best ten, etc. I have only taken so much of the table as would include a voyage of four months, since a vessel could hardly be without means of correcting her chronometer for a much longer time than this. We may fairly say that this table

represents the danger which the merchant-ships of Liverpool actually were subjected to for many years on account of erroneous running of their chronometers, and because the sea-rates varied from the shore-rates. It must also be remembered that from this table all cases of vessels which were shipwrecked (on this and other accounts) are omitted, so that, no matter how impossible it may at first sight seem to be that such enormous errors existed, it is yet a matter of fact that the errors are *under* and not *over stated.*

Table showing Error of Longitude in Geographical Miles on the Equator, deduced from 1,700 *Chronometers.*

LENGTH OF VOYAGE.	One Month.	Two Months.	Three Months.	Four Months.
Average error from 1,700 chronometers	6	14	23	33
Average error from the best 10 in 100	0	0	1	1
Average error from the second best 10 in 100	1	2	3	4
Average error from the third best 10 in 100	1	4	6	8
Average error from the fourth best 10 in 100	2	5	9	13
Average error from the fifth best 10 in 100	3	7	12	17
Average error from the sixth best 10 in 100	4	9	15	22
Average error from the seventh best 10 in 100	5	11	18	28
Average error from the eighth best 10 in 100	7	15	25	36
Average error from the ninth best 10 in 100	9	24	41	61
Average error from the worst 10 in 100	25	62	101	143

Examining the table in detail, it becomes necessary to recollect that it is a matter of record that these actually were the errors of chronometers carried on a large number of ships sailing out of Liverpool. The average errors derived from no less than 1,700 chronometers are enormous, being as great as thirty-three miles for a voyage of four months.

Among the many vessels carrying these instruments were a large number going on long voyages to India, Australia, and South America, and in many cases these vessels would necessarily be between three and four months or more on the voyage, often without sighting land. It appears from this table that the average error to be *expected* on such a voyage, and with such chronometers as they had (up to 1863), was no less than thirty-three miles! It is plain that no such errors are to be found in the chronometers used by our own naval vessels, nor were American merchant-vessels during the same period so badly provided for, but it is certain that English vessels were provided on the whole with extremely poor instruments.

It is plain that several causes were here acting. The chronometers furnished to these ships were on the average very poor. This fault

could be remedied by a board of inspection appointed by the insurance companies, which should refuse to insure the cargo or hull of any sea-going ship unless her chronometers were found, after trial, to be satisfactory. Part of the error is undoubtedly due to the bad navigation of the captain, who, in distant ports not provided with time from an astronomical observatory, determined the error of his chronometer himself, and that not always correctly. But the great source of error was the fact that the *rate* of the chronometer assigned at the port of sailing did not serve throughout the voyage.

It will be then of some interest to describe the measures now taking in the United States to provide the sea-going ships sailing from our various ports with an accurate standard time; and, further, to explain the facilities offered by the United States Naval Observatory to railways, manufactories, and others, in the providing of a time by which to regulate their affairs.

The Superintendent of the Naval Observatory, the late Rear-Admiral C. H. Davis, some time ago proposed to the authorities of the Western Union Telegraph Company the erection of a large time-ball upon their new building on Broadway, near the City Hall. This time-ball it was proposed to drop daily by telegraph at New York noon. It is to be dropped exactly at $11^h\ 47^m\ 49.53^s$ A. M. of Washington local time, which is New York noon, $12^h\ 0^m\ 0.00^s$, or $4^h\ 56^m\ 1.65^s$ of Greenwich time. It will thus be available both for the citizens, railways, etc., of New York, and for the ships sailing from port It is to be mounted upon the large iron flagstaff on top of the east tower of the Western Union building, the base of the staff being about 230 feet above the street, and the ball being dropped from a part of the staff about 25 feet above this. The whole expense of the apparatus, which is considerable, and the management of it, which requires the attention of a laborer and of a skilled electrician, have been assumed in a public-spirited manner by the Western Union Telegraph Company, for the benefit of the citizens and the shipping of New York City.

The apparatus employed may be briefly described as follows:

Around the iron mast, which is of great strength, is fastened an iron jacket, sliding up and down freely upon it. On this is fitted a ball three feet six inches in diameter, made of copper-wire netting, and painted black. The interstices of the netting allow of a free passage of the wind through the ball, so that less strain is exerted upon the mast, and a larger ball is permissible than there otherwise would be.

At the bottom of the jacket are a coiled spring and a buffer encircling the mast, which take the considerable blow of the falling ball. At $11^h\ 55^m$ of New York time, the ball is hoisted half-way or more up the mast, and at $11^h\ 58^m$ it is hoisted completely up, and the halliards are attached at $11^h\ 59^m$ to a lever actuated by an electro-magnet. At exactly noon an electric signal releases the lever, and the ball falls by its own weight.

If by any mischance the ball does not so fall at noon, it is kept up to its place until $12^h\ 5^m\ 0^s$, when it is dropped. To signalize this programme, which may occasionally be necessary, a small flag marked $12^h\ 5^m$ will be at once hoisted, and kept flying till the ball is dropped. A ball of this size can be seen by every vessel lying at the wharves of Brooklyn and New York, either in the North or East River, and by every vessel in the bay, even beyond Quarantine, if the ordinary night-glass is employed.

At the instant of the fall their chronometers should indicate $4^h\ 56^m\ 1.65^s$ (Greenwich time), and the difference between this time and what their chronometers really give is the correction to them. Daily observations of the fall of this ball will give the daily gain or loss of the chronometers; that is, their rates.

A capital advantage will be that such corrections and rates can be determined without removing the chronometer from the ship, so that a fertile source of disturbance which accompanies the carriage of the chronometer to and from the vessel is thus, in future, avoidable. To the citizens of New York and Brooklyn the ball is widely visible. It can be seen on Broadway from Grace Church nearly to the Battery, and a suitable position can be found nearly anywhere in the city from which its face can be observed.

Incidental to this programme, and as an immediate consequence of it, the means of securing an accurate agreement of clocks throughout the city is at hand. The Western Union Company will agree to control electrically other clocks in New York City and vicinity, so that they shall constantly indicate the standard time. One means of doing this is so simple that it deserves mention. Each clock to be so controlled has an attachment contrived so that when its hands arrive at the position $12^h\ 0^m$ M., a small pin is thrown out through a hole in the clock-face just in front of the minute-hand, which is thus held fast at twelve o'clock. The outer end of the hand is held fast, but the axis on which the inner end is placed keeps on turning, so that the clock-train is not interfered with. This is the mechanical arrangement. The practical working of the system is as follows: Each clock is regulated so as to gain from ten to thirty seconds daily; therefore, when its hands reach noon, it is not really noon, but lacks from ten to thirty seconds of it. The pin is protruded, and fastens the minute-hand in its place till it is withdrawn by an electric signal from the regulating or motor clock, and then all the hands start together, and continue to move for twenty-four hours, gaining their ten or twenty seconds in time for a repetition of the process on the next day. This beautiful and simple device, invented by Bain, has another advantage —that of cheapness—for it requires the use of the wire from the controlling clock but for an instant each day, and, in a crowded city like New York, the expense of erecting and maintaining the necessary telegraphic wire from each clock to the controlling clock is a minimum.

Some similar system should be adopted by railways leading out of New York, whose standard clocks could be connected at a trifling expense with the main clock, and kept right to within less than thirty seconds, which is near enough for most purposes. It should not be forgotten that each clock so controlled has the same accuracy as if it were directly controlled by the standard astronomical clock of the Naval Observatory at Washington, since the time which is obtained at that institution is directly distributed throughout the system.

For railways this system is peculiarly advantageous. Most railways adopt the time of one city as the standard time, by which all trains are run, and to which the watches of all employés are adjusted.

Suppose this should not be New York time, but another, as Poughkeepsie time, for example. A simple device, lately proposed by an ingenious writer in the *New York Tribune*, enables the New York clock to be controlled to both times. This consists of a double minute-hand—that is, instead of making a single minute-hand, make it double, with two pointers, so that when one points to New York time, the other points to Poughkeepsie time. The controlling stop, or pin, acts upon the New York minute-hand, but the other hand is equally kept right.

Such a clock will serve to control in its turn all the clocks along the line of the railway by a daily signal, so that at every railway-station the station-master's clock indicates, say, Poughkeepsie time. If required for the benefit of the citizens of each place, a second minute-hand can be added to each of these secondary clocks, so that the local time of each station can be indicated, while at the same time each railway-clock affords the means to each railway-employé of correcting his own watch. This system, so simple in theory, is equally simple in practice, and requires nothing but the care and fidelity of the agents to whom its execution is confided to make it eminently useful and beneficial. It should be remembered, however, that to carry out its provisions carelessly is to commit a positive crime, since so much depends upon its results. Similar systems of control are now provided in many places. The observatory at Washington controls several clocks in the various departments; and in London, Edinburgh, Paris, Vienna, Bern, and elsewhere, this work is successfully carried on.

The distribution of time-signals (either with or without *controlled* clocks) to railways, etc., is a most important matter, in which the United States is far behind England, for example, where about five hundred railway-stations receive a signal daily. This is partly due to the enormous extent of America in longitude, so that very different local times are used at different places of the same continuous railway-line, and partly to the fact that the telegraphs are owned by the Government in England, thus rendering the execution of a general system of time-signals comparatively easy. In the opinion of many experienced and prominent railway-officials in the United States, it is quite

feasible and very desirable for all railways to be operated by one common time, and the first step toward this is plainly the *certainty* that the time-signals which are now regularly sent from the Naval Observatory shall reach each railway-station once daily, at least.

It should be remarked that this change, as well as the changes it would imply, and which would follow as natural consequences, is not by any means so violent as the change from the English system of measures (feet, pounds, bushels, etc.) to the metric system (metres, grammes, litres, etc.) often proposed, and now partially adopted. In the latter case, the *units* are altered, and for the first generation, at least, continual reference will have to be made from the old system to the new; whereas, in the first case, the units remain the same, and the point of reference only is changed. Once familiarize a citizen of Detroit with the fact that his local mean noon is to be called $12^h\ 24^m$ instead of $12^h\ 0^m$, and the transition would hardly be noticed. If by any chance all watches, clocks, and time-keepers in New York City could simultaneously be turned back $12^m\ 10.5^s$ (i. e., to Washington time) unknown to their owners, it is probable that the number of people who would be aware of the change would be extremely small.

Besides sending the signals which regulate the New York clock of the Western Union Telegraph Company, the Naval Observatory at Washington has for several years sent daily (except Sundays) a telegraphic signal at Washington noon over the lines of the Western Union, which signal is already widely distributed.

To increase the usefulness of this signal, Admiral Davis entered into arrangements with the officials of the Western Union Telegraph Company by which they will contract to deliver such a signal daily to subscribers (for a year) at extremely low rates. The company will connect the house, office, or manufactory of the subscriber with its local office (for the present the arrangement is confined to offices in towns having 20,000 inhabitants or over) in his town for a sum to be settled according to the length of wire required, etc., and will furnish him with a telegraphic sounder, or such other form of apparatus as may be suitable.

The price of such a connection is to be settled according to the various circumstances of each case, and each subscriber will of course bear the necessary expense, which will be met in the form of an annual rental. Besides this charge peculiar to each subscriber, the company will charge a certain small sum for transmitting the Washington noon signal to its own office for distribution; and this sum, if there is but one subscriber in any town, must be paid by him. Two subscribers halve the expense, for three each pays one-third, and so on. For New York and other large cities this expense will be almost nothing, so that the real cost of a transmission of the Washington noon signal will practically be the annual rental of the wire used to connect the subscriber's premises with the telegraph-office. By the method of

double hands before described, this Washington noon signal may be used to control a clock by the Bain or some other system in a house, or manufactory, or railway-station, and a general acceptance of Washington (or any other) standard time by which to regulate the running of railway-trains or other affairs is rendered easy and safe if it is desirable to make this change.

The advantages of a general use of this system are very great, and will be evident on a slight consideration. The arrangements proposed by the Naval Observatory are not intended to conflict, and they do not conflict, with others more local adopted and successfully carried on by various observatories.

Among these, the more prominent are the Harvard College Observatory, which, under the direction of the late Prof. Winlock, instituted a system of time-distribution to the various railways of Boston and vicinity, which has been for some years in successful operation; the Allegheny Observatory, of Pittsburg, which, under its director, Prof. Langley, has also for some years furnished standard time to the Pennsylvania and other railways; as well as the observatories of Cincinnati, Albany, and others.

The coöperation of all these institutions will undoubtedly result in providing for a more extensive and better-organized system than has hitherto been possible, and some of the benefits to be derived from such a coöperation have been pointed out. The establishment of time-balls at our various seaports, Boston, Baltimore, Philadelphia, Norfolk,[1] Charleston, Savannah, New Orleans, etc., is most important, and insurance companies, shippers, and owners of vessels, could well afford to bear the small necessary expense, which would be more than repaid to them by the additional safety given to navigation.

The extension of a system such as exists in New York to the various seaports of the country could not but secure a greater safety to sea-going vessels and an increased security to the traveling public, two objects worthy of all attention.

[1] Time guns or balls, at Hampton Roads and the Delaware Breakwater, are peculiarly demanded by commerce, but would have to be supported by underwriters and shippers, as there will be little demand for them from the neighboring population.

A time-gun at Hampton Roads would be used by all vessels proceeding on long voyages from Baltimore, the Potomac, and Richmond, and by the large number of ships calling at Hampton Roads for orders where to carry their cargoes. It would be particularly valuable to ships using this roadstead as a harbor of refuge on their voyages, which ships at present seldom or never wait for fair weather to rate their chronometers, but, on the first appearance of settled weather, slip out to sea to continue their voyages.

MATTER AND MIND.

By FRANCES EMILY WHITE, M. D.

UNDER cover of the words placed at the head of this paper, it is proposed to call attention to a few only of the more salient points involved in the subject, and especially to those suggested in a recent article in this journal,[1] in which the attempt is made to apply the principle of correlation to certain forces (called indifferently mental and spiritual), without recognizing that highly-important factor in the manifestation of all known force, viz., matter.

In examining any subject from what claims to be a scientific point of view, established facts must not be ignored; and in proportion to the importance of the question which science is called upon to answer, should be the exactness of the solution offered.

It has been conclusively shown, by experimental methods similar to those employed in demonstrating other correlations, that emotion and thought are correlated with heat and electricity;[2] and the correlation between *thought* and *mass motion*, through the action of nerve and muscle, is constantly exhibited in the human body. It must, then, be admitted that these forces (thought, etc.), like those with which they are correlated, are manifestations of matter.

The scientist knows of no mode of energy manifested in any other way than through matter; and the supposed "cycle of operations in which there is no annihilation of spiritual force" must be regarded, not as a cycle, but rather as a segment of the great cycle which includes all natural phenomena.

The idea of annihilation either of matter or of force is inadmissible to science; but there is a constant shifting—a disappearing and reappearing—of different modes of energy, corresponding to the unceasing mutations of matter; the special force manifested in any given case depending on the kinds and conditions of the matter involved.

The supposition of other kinds of force, differing from those recognized by the physicist, implies either different kinds of matter, or the same kinds differently conditioned.

The relations of the different parts of an organism to each other, and of the entire organism to its environment (the environment including other organisms, as well as inorganic matter), must all be scrutinized when we attempt to trace the source of the power manifested by any organism. A symphony of Beethoven is made up of bars and interludes—of points and rests—of quavers and semiquavers

[1] "On the Annihilation of the Mind," by Prof. John Trowbridge, Popular Science Monthly, April, 1877.

[2] University Series, No. 2, "Correlation of Vital and Physical Forces," by George F. Barker, M. D.

—like any other, even the simplest piece of music. How, then, does it differ from every other musical composition? Among which of its parts shall we look for the grandeur of movement, the rush of harmonies, and the eloquence, more powerful than that of words, which, as it thrills the metallic strings, awakens responsive vibrations among those differently constituted and conditioned strings which form the organ of hearing, and through this organ arouses emotions among the deepest of which our natures are susceptible? It is true, the effects produced are but poorly represented in the symbols of the musical score, or in the strings of the instrument which respond to the performer's touch; these elements are, however, not only important, but absolutely essential to the production of the results, and they must not be ignored in the statement of the problem with which we have to deal. When, however, we attempt to follow the transformations of energy which have taken place between the first and last links of the chain connecting the brain of the composer with that of the listener, we are lost in a maze of hopeless intricacy—hopeless, because we are unable to include in our limited grasp the innumerable threads which together constitute the clew to the labyrinth.

Nevertheless, we are compelled to believe that a clew exists, and that it depends on these twin principles—the *correlation of forces*, and the *inseparableness of force and matter*—since each link in this seemingly endless chain, when separately examined, is found to connect with some form of matter and some kind of force, with both of which we are more or less familiar.

Functions of mind cannot be formulated in terms of matter—there is no correlation in the language employed; but this is equally true of other phenomena—as, for example, of combustion. We know that chemical reaction between carbon and oxygen results in heat-production; and we know that certain combinations of vibrations of musical strings, communicated to the membrana tympani of the human ear, result in the production of emotions. It is safe to promise an explanation of the latter phenomenon, whenever an explanation of the former shall be forthcoming.

The phrase "principle of life" is deceptive; the expression "manifestation of life" means something definite, since life may be regarded as the sum of the forces manifested by certain forms of matter brought into certain relations with each other, and with the environment; but a "principle of life," although it may be talked about, cannot be located nor described; it is a phrase, *et prœterea nihil.*

That which is called *the ego*—the sum of the various elements which make up the character—cannot, from a scientific point of view, be regarded as an entity, unless the combined forces and powers of any machine may be so regarded.

When a machine is taken to pieces, or falls into decay, what becomes of the forces previously manifested by it? Have they gone off,

in some associated way, to manifest themselves elsewhere in manufacturing carpets, impelling railroad-trains, or printing newspapers, as determined by the original construction of the machine which they have deserted? This question belongs as legitimately to science as the one discussed in the article previously referred to; for the scientist has no knowledge of mind apart from the brain which manifests it.

The same writer attempts a projection, upon the screen of thought, of "a great source of life and mind, the prototype of our physical sun," which may be supposed to hold the same relation to the world of human thought that the sun holds to our world of matter.

The relations of the sun's heat and light to the energies of our planet (including the forces manifested by the organisms developed from its crust and atmosphere) are correlations, in which the forces concerned are mutually convertible; moreover, the energies displayed by living bodies are of a higher order than are those of the sun (heat, light, etc.) through whose influence these living energies are developed.

Where, then, does such a simile lead? If the forces emanating from this great source of life and mind are convertible into human energies, then—according to the same law—human energies are convertible into those of the prototype. No new principle is introduced by such a conception, and, in order to make the figure good, the forces of the prototype must even be regarded as of a lower order than human energies.

The human brain presents the most complex and highly-organized form of matter known. Its relations and means of communication with the other less complex organs which make up the entire body are most subtile and intimate; through the organs of the special senses it is also brought into communication with an environment limited only by the range of vision, which is extended, by telescope and microscope, to the nebulosities which belong to immensity on the one hand, and to the obscurities of the infinitesimal on the other.

The energies displayed by this remarkable organ hold a rank among known forces comparable, in range and complexity, to its structural superiority over other forms and combinations of matter. These forces, so far as they come within the range of scientific observation, hold the same sort of relation to the material organism that the force called magnetism bears to the magnet, or heat to the body from which it emanates.

Beyond this relation, Science has no testimony to offer.

GAR-PIKES, OLD AND YOUNG.

By Professor BURT G. WILDER,
OF CORNELL UNIVERSITY.

II.

THE writer's opportunities for observing the motions of the adult gar were too brief to enable him to describe them accurately. It is to be hoped that this fish may soon be placed in some public aquarium. But the motions of several young gars were carefully watched daily during three weeks.

The movements of the little gars, even the smallest, were very unlike those of the common little fishes, minnows or catfishes, which were placed with them. These latter seemed agitated, and splashed about in an indeterminate way. But the little gars, though they went like arrows when disturbed, usually remained almost at rest, or moved slowly about with a dignified, almost solemn air, as if conscious of very ancient and honorable lineage. They also have, as was remarked by Prof. Agassiz, the power of moving the head upon the neck; and occasionally the whole body was thrown into two or three undulations, resembling those of a short serpent; and so impressive is the air of supercilious self-possession that one might almost imagine them shrugging their shoulders at other creatures, including the bipeds of recent creation, who study their movements.

To sounds in general they paid no attention. But a tap upon the side of the vessel usually caused them to start and open the mouth, sometimes two or three times in succession.

It has already been said that the little gar first taken was recognized as such; yet the resemblance to the adult was mostly in the general elongated form of the body, and in several other respects there were marked differences. First, in *color*. The old gar is a bluish ash-color, or light gray; darker above, and lighter below, but with no distinct patches. All of the young gars presented a distinct though irregular dark stripe along the side of the body and head, crossing the eye. The belly, too, was almost white, and strongly contrasted with the darker regions.

Second, the smallest ones had *no scales* at all; but with one, 108 millimetres (about four and a quarter inches) long, the hinder half of the body showed outlines of the scales in process of formation, and the larger ones had the armor more or less fully developed. At about the same time the upper and lower borders of the tail become protected by several pair of pointed plates, the *fulcra*.

The third and most striking peculiarity of the young gars con-

sisted in the existence of *two tails*, an upper and a lower. These are shown in Fig. 8, *B*.

The formation of these two tails, and their significance, will be considered further on; for the present, we are concerned with their structure, their relative position, and their uses. The lower tail was

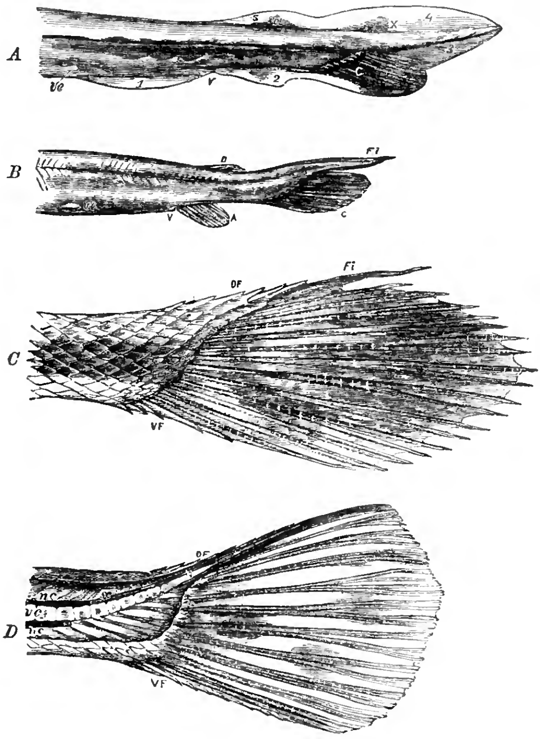


FIG. 8.—FOUR FIGURES OF THE TAILS OF *Lepidosteus* AT DIFFERENT STAGES.

A, from a specimen twenty-two millimetres or seven-eighths inch long, enlarged four diameters. The ventral fin (*Ve*) is just appearing. The median fin is being absorbed between the four spots referred to in Fig. 9. The tip of the tail is inclined upward, and the infra-caudal lobe is larger. In *B* the primordial fin has almost disappeared; the dorsal (*D*) and the anal (*A*) fins are quite large. The infra-caudal lobe is nearly as long as the tip of the original tail, which has been reduced to a slender vibratile filament. This specimen is forty-four millimetres or one and three-fourths inch long, and the tail is enlarged two diameters. *C* shows the tail of a specimen three hundred millimetres or nearly twelve inches long, of natural size. The filament is still further reduced, and the rays of the infra-caudal lobe form the end of the tail. In *D* the tail is that of an adult, one-half natural diameter. The filament, the original end of the body, has wholly disappeared, and the infra-caudal lobe forms the tail. But dissection shows the spinal axis extending along the dorsal border to a point corresponding with the previous attachment of the filament. (Further description and discussion of these changes, with references to authors, may be found in a paper by the author, entitled "Notes on the North American Ganoids." "Proceedings of the American Association for the Advancement of Science," 1875, pp. 151-193.)

evidently the caudal fin. It had several rays, and a rounded hinder border. But it was smaller in proportion than in the adult gar, and the middle rays were directed obliquely downward, instead of horizontally backward.

The upper tail is best described as a single fleshy filament, flat-

tened from side to side, and tapering to a fine extremity. In the smallest gars it was longer than the fin below, in the older it was shorter, while in the adults no trace of it appears.

These two tails have very different movements. The lower, corresponding to the caudal fin of the ordinary fish, is used in three ways. When the little gar is in a gentle current, and wishes not to be carried downward, the fin is made to execute a series of undulatory movements, such as have been described by Prof. Agassiz respecting the dorsal fins of young pipe-fishes, etc., and such as the writer has observed with the long dorsal fin of *Amia*.

This tail is also strongly flexed to one side, as with ordinary fishes, in order to change the course. And it is rapidly moved from side to side for all sudden and rapid locomotion, as when frightened.

The movements of the filament were first described by Prof. Agassiz, and he called attention to them upon several occasions. But his descriptions are very brief, and, upon one point, seem to require modification.

The filament is in almost constant vibration. Occasionally, when the gar is at rest, and perhaps also when it is turning, or rapidly swimming, the filament is not used. But usually the vibrations are so rapid that the tip of the filament is invisible, excepting as an indistinct blur. Generally, it is directed backward and slightly upward, but at times it is bent to one side, or elevated to nearly a right angle with the body, the tip all the while in constant vibration. Those who have watched the tail of an irritated rattlesnake, or even of a common striped snake, under strong excitement, may form a pretty correct idea of the nature of this movement. It was characterized by Prof. Agassiz as "involuntary;" and so it may be regarded, since its rapidity is such as to preclude the idea of a separate volition for each movement. But the gar, evidently, has entire control of the vibrations; for they are more or less rapid at different times, and are occasionally intermitted; the position of the whole filament is changed at will; finally, the muscular bands upon each side of the cartilaginous rod, which runs through the filament, consist of the striped variety of muscular fibre, as are the other voluntary muscles.

This is all the writer has seen of living young gar-pikes. But the explanation of the peculiar double tail is furnished by some still younger specimens, the smallest of which is shown, enlarged, in Fig. 9.

These little gars were scooped out of the Red River, near Shreveport, Louisiana, in the spring of 1871, by a lad only ten years old, who had heard the writer say that he wished for very *small* fishes. At that point these young gars were then as abundant as minnows, as easy to catch, and commercially as worthless. All of them are less than two inches long, and among them are two about three-fourths of an inch in length. These last are not only much smaller than any

previously examined by naturalists (so far as known to the writer), but they also furnish the clew to the double tail, and suggest some important paleontological considerations.

While earnestly expressing his appreciation of the value of these little gars, the writer finds himself compelled to exemplify the proverbially ungrateful and dissatisfied nature of zoölogists by regretting that there were not more of them, and that some were not very much smaller, or even still within the egg.

In this connection one is reminded that now, as a rule, the smallest rather than the largest are desired by naturalists. The giants are curiosities, and interesting as showing the capacity for *growth;* but the mysteries of development, the relations of apparently diverse forms, and the order of geological succession, are best revealed by the apparently most insignificant.

A good illustration of this inverse ratio between size and value is contained in the following passage from Prof. and Mrs. Agassiz's "Journey in Brazil:"

> "Mr. Agassiz has a corps of little boys engaged in catching the tiniest fishes, so insignificant in size that the regular fishermen, who can never be made to understand that a fish which is not good to eat can serve any useful purpose, always throw them away. Nevertheless, these are among the most instructive specimens for the ichthyologist, because they often reveal the relations not only between parent and offspring, but wider relations between groups."

Of the two smallest gars, one is nearly colorless, while the other is marked very much as are the older ones. They are 18 millimetres (a little less than three-fourths of an inch) in length. The head is short and flattened, with slight indications of teeth on the edges of the jaws. With one of them the ventral fins have not appeared; with the other they are represented by minute white elevations. Each pectoral consists of a fleshy lobe, surrounded by a thin fringe or border.

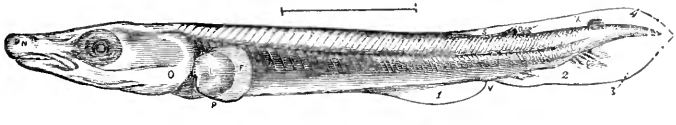


FIG. 9.—SMALLEST GAR-PIKE YET OBTAINED (EIGHTEEN MILLIMETRES OR ABOUT THREE-FOURTH INCH LONG, ENLARGED FIVE DIAMETERS).

The actual length is indicated by the line above the figure. There are no scales. The head is short. The pectoral fin (*P*) consists of a fleshy lobe (*L*), with a thin fringe or border (*F*). The ventral fins have not appeared. A median fin extends along the hinder third of the body above and the hinder half below. It is interrupted by the vent (*V*), and presents four darker and more or less differentiated spots. The anterior pair are evidently the beginnings of the dorsal (*D*) and anal fins. The signification of the hinder dorsal spot is uncertain. But the hinder spot below (*C*) presents rays, and is the commencement of the infra-caudal lobe.

The hinder end of the body tapers to a point, as with *Amphioxus*, the extremity being slightly bent downward. At the junction of the middle with the hinder third of the body commences a delicate median fin, colorless, and without rays for the most part, and extend-

ing around the tip of the tail forward to the vent, thence forward to about the middle of the body. Such a primordial median fin exists in the young of all fishes whose development has been studied. The permanent fins seem to result from the formation of cartilaginous or bony rays either throughout most or the whole of its length, as with lampreys and common eels; or at several points, as with the mackerel and *Polypterus;* or at three, or two, or only one, as with the cod, the blue-fish, and the pickerel. The intervening portions disappear. The hinder part of the primordial fin of the smallest gars presents four points of darker coloration, two above and two below. The posterior upper spot presents no rays, and later seems to disappear.[1] The other three are evidently the beginnings of fins. The anterior above and that below occupy the positions of the future dorsal and anal fins. The destiny of the hinder lower spot is better seen by comparison with larger examples.

The series given in Figs. 8 and 9 shows that, as the gar increases in length, the primordial fin disappears, the dorsal and anal increase, and the end of the tail becomes more slender and pointed. But the most striking change consists in the enlargement of the hinder lower spot into what may be called the infra-caudal lobe. The rays of this become longer and more numerous. They project beyond the margin of the primordial fin, so as to leave a decided notch, as in Fig. 8, *A*.

In Fig. 8, *B*, the end of the body merits the name of filament, and the relative size of it and the lobe is reversed. Afterward, partly by more rapid increase of the lobe, and partly by absorption of the filament, the latter seems smaller and smaller, and at last disappears; so that the lobe, from having been at first an outgrowth from the filament, finally becomes the whole of the tail or caudal fin.

It appears, then, that the hinder end of the body undergoes considerable change before reaching the adult condition. Aside from the partial disappearance of the primordial median fin and the gradual development of the ventrals, the dorsals, and the anal, the caudal fin assumes at least three distinct forms. The first is lance-shaped and simple, like that of *Amphioxus*, the eel, the lamprey, salamanders, and tadpoles. The second is compound, with a slender filament above and a broader fin below, as with some sturgeons and sharks. The third consists entirely of the lower fin, which is enlarged and brought into a direct line with the body, the longest rays being a little above the middle. Its upper and lower borders are now thicker and stronger than the intermediate portions; whereas in the first stage the cartilage and muscle are in the centre, the upper and lower borders being very thin.

In short, the tail of the gar-pike undergoes a decided *transformation.* And one naturally inquires, "What is the occasion for it?"

[1] It may have a morphological significance, as suggested further on respecting the fossil *Glyptolœmus.*

It is so recently that all structural differences and changes were supposed to be readily explicable upon the doctrine of final causes, that we naturally turn first in that direction. Some transformations certainly seem to relate very distinctly to the welfare of the individual, as when the caterpillar becomes a butterfly, and when the aquatic larvæ of mosquito and dragon-fly change their forms with their habits and modes of life. So, among the vertebrates, it is obvious that the tadpole is by no means adapted to the necessities of the frog and the toad; and the intermediate stages, resulting from the gradual loss of the tail and the acquisition of legs, while perhaps not particularly suited to either aquatic or terrestrial locomotion, seem to be required in order to permit the development of the lungs and the accompanying disappearance of the gills.

But can the transformations of the gar-pike's tail be thus accounted for? According to present knowledge and justifiable inference, the *Lepidosteus* not only passes the whole of its life in the water, but is also, from first to last, an active, predaceous fish, requiring all possible advantages of form and fin in order to overtake its prey.

Since no marked change occurs in the general form of the body, we may perhaps assume that it is perfectly well adapted to the fish's needs; although this suggests the general inquiry as to the *cui bono* of the almost infinite variations from the ideal form supposed to be best suited to aquatic locomotion.

But do we know, or can we easily infer, any differences in the necessities or the manner of life of the *Lepidosteus* at different ages, which may account for its having a tail first like a lamprey's, then like a sturgeon's, and, finally, like that of *Amia?*

It may be suggested that the rapid and, at most, invisible vibrations of the filament enable the young gar to glide stealthily upon its prey. But the very young would seem to be even more in need of such precaution, and with them the tail is relatively as large as in the adult, although differently shaped. Finally, even if we conclude that the three distinct stages of the tail are perfectly adapted to certain hypothetically unlike necessities, what shall be said of the intermediate conditions? While growing, the infra-caudal lobe must be rather a hinderance than a help to the movements of the primitive tail; and while disappearing, the filament, being useless, must be, if anything, an incumbrance.

Shall we, then, conclude that these changes in the appearance of a single individual are for the sake of *variety*—as some would explain the great diversity of specific form and coloration among animals and plants?

At the present day, neither of the explanations above given is likely to wholly satisfy the large class of thinkers who, whether or not they accept any particular evolution doctrine, are inclined to believe that there is, in many cases, a more or less exact parallelism between

the changes which occur in the development of an individual, the successive forms of geological times, and the series of living forms, lower and higher, or more generalized and more specialized.

In the smallest gar here described, and presumably in still younger examples, the axis of the body, represented by the notochord or primitive vertebral column, is nearly horizontal, about midway between the upper and the lower borders of the tail. This is likewise the case with the lowest known vertebrate, *Amphioxus;* with the forms next above, the hag-fishes (*Myxine* and *Bdellostoma*) and lamprey-eels (*Petromyzon*); with the larvæ (tadpoles) of frogs and toads; and with the adults of the aquatic and tadpole-like salamanders, *Menopoma* and *Menobranchus.*

Finally, such a tail exists in the Dipnoans, or mud-fishes, of Africa, South America, and Australia (*Protopterus*, *Lepidosiren*, and *Ceratodus*), which have some striking affinities with Batrachians, but are usually regarded as fishes, and are, perhaps, the best illustration of *generalized* forms.

To this variety of tail, Cope has applied the name *isocercal;* Huxley calls it *diphycercal*, and gives as an example *Polypterus*, where, however (as in *Calamoichthys*), the "end of the notochord is hardly at all bent up." Wyman, finding this kind of tail in the embryo of a skate, called it *protocercal,* and, on some accounts, this seems the more suitable name.

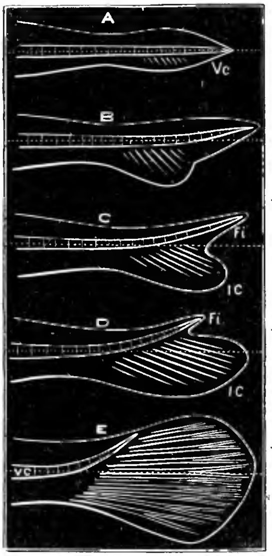
As the gars grow older, the relative length of the filament and the infra-caudal lobe constantly changes. At first the former is the longer; in a specimen 108 millimetres long, their tips coincide; in one 142 millimetres long, the lobe projects beyond the filament; and in a third, 300 millimetres long, the filament is much the shorter, is ragged and attenuated, and during life was rarely employed. This second stage, or rather series of stages, has several counterparts among living Selachians and Ganoids. The most accurate resemblance is presented by the shovel-nosed sturgeon of the Mississippi River (*Scaphyrhynchus*). The filament is excessively elongated in *Chimera*, and exaggerated as to both length and breadth in the thrashing-shark (*Alopias*). But, with many sharks, the common sturgeons, and the spoonbill (*Polyodon*), the size of the infra-caudal lobe is so nearly that of the filament as to give the whole tail a nearly symmetrical outline, and lead zoölogists to speak of the "upper lobe," whereas it is really the bent-up end of the body. This kind of tail is called *heterocercal.*

The gars above mentioned are supposed to be the young of the *Lepidosteus osseus.* Just at what size the filament wholly disappears in that species is not known. But with the smaller and proportionally shorter species, *L. platystomus*, there is no sign of the filament when eighteen inches in length. The tail might then be thought, at first sight, to be symmetrical. But the longest rays are a little above the

middle, and dissection shows that the spinal axis is continued backward and upward as a cartilaginous rod,[1] terminating at the upper border, just under the hinder pair of *fulcra*, and at the point where the filament was attached. The rays are all attached to the lower border of the spine; and there is only a lower lobe of the tail.

A similar structure exists in the tail of *Amia*, which Prof. Huxley gives as an example of *heterocercal* tail. It seems better, however, to discriminate between it and the previous stage, where the upper lobe (filament) exists, and it may, therefore, provisionally be called the *masked heterocercal*, or perhaps the pseudo-homocercal.

Prof. Huxley has more recently given figures and descriptions of the tail of embryo Teleosts (*Gasterosteus*), in which the structure is nearly identical with that of the adult *Amia* and *Lepidosteus*.[2]



A. Protocercal. First stage of *Lepidosteus*. Permanent in *Amphioxus*, *Petromyzon*. *Lepidosiren*, *Polypterus*. Also in some ancient Ganoids, as *Glyptolæmus*.

B and *C*. Heterocercal. In the sturgeons, and most sharks, and many mesozoic fossils.

D. Not represented, so far as I know, among recent or fossil forms.

E. Masked heterocercal. In adult *Amia* and *Lepidosteus*. In the embryo of many Teleosts. In *Megalurus* and some other fossils of Mesozoic and more recent epochs.

FIG. 10.—DIAGRAMS INTENDED TO ILLUSTRATE THE CORRESPONDENCE OF THE SUCCESSIVE STAGES OF TRANSFORMATION OF THE TAIL OF *Lepidosteus*, WITH THE TAILS OF CERTAIN LIVING FORMS MORE AND LESS GENERALIZED, AND OF CERTAIN FOSSILS MORE AND LESS ANCIENT.

A, the first or *protocercal* stage, where the end of the vertebral column (*Vc*) is horizontal and divides the tail into upper and lower lobes nearly equal in size. *B* and *C*, the heterocercal stage, where the original tail is more or less elevated by the lower or infra-caudal lobe (*IC*), and becomes the filament (*Fi*), usually called the "upper lobe." In *D* the infra-caudal lobe is longer than the filament, and in *E* the latter has wholly disappeared, and the tail assumes the last or "masked heterocercal" condition.

The same author concludes that in many adult Teleosts the posterior end of the spine is more or less strongly bent up, although the tail is outwardly nearly or quite symmetrical.

[1] This rod consists of the notochord, and a slender prolongation of the spinal cord, surrounded by a cartilaginous sheath.

[2] The writer has found the same condition in newly-hatched catfishes (*Amiurus*), and it has been observed in the embryo of a species of *Cottus*, by Mr. S. H. Gage, a student of natural history at Cornell University.

But when, as in the majority of species, the hinder border is emarginate, so as to form an upper and a lower lobe, the former is never known to contain any extension of the spine; although some South American Goniodonts have the upper ray prolonged into a sort of filament, yet in other forms the lower ray is similarly elongated, and neither can be compared with the true filament of the young gar or the upper lobe of sturgeons and sharks.

It may not be possible to draw a sharp line between the tail of most adult Teleosts, and that of *Amia* and *Lepidosteus*, but perhaps the old term *homocercal* can be employed for the former.

Upon the whole, it would appear that the tail of the youngest *Lepidosteus* is protocercal like those of the lowest vertebrates and the generalized forms called Dipnoans; that the second or obviously heterocercal stage is comparable with the tails of sharks and sturgeons, while the last stage seems to correspond quite closely with that of the teleostean embryo. And, as the Teleosts are almost universally regarded as the most specialized group of fishes, there appears to be a pretty close agreement between the successive stages of *Lepidosteus* and the rank of the forms or groups with which comparison has here been made.

The corresponding geological series is less complete and satisfactory. No forms resembling *Amphioxus* or the hag-fishes and lampreys have yet been found fossil, although all, excepting the former, have horny teeth, of which, it would seem, some traces might well be preserved.

But among the oldest fishes are some described by Huxley whose tails are apparently protocercal. The resemblance to the earliest stage of *Lepidosteus* is emphasized also by the existence of two dorsals and two anals.

Fossil species of *Amia* and *Lepidosteus* have recently been discovered by Prof. Marsh in the Tertiaries of Western America. The *Megalurus* of the European rocks had a tail strongly resembling that of *Amia*, but this kind of tail is not known among the palæozoic rocks, and Teleosts are first found in the Cretaceous, becoming more and more numerous up to the present time.

But among the earliest known fossil fishes are some in which the end of the spine is not at all bent up; the tail is protocercal. And, with two genera (*Glyptolæmus* and *Gyroptychius*) described by Prof. Huxley, it may be possible to determine the correspondence between the two dorsals and anals and the two pair of differentiated spots upon the primordial median fin of the youngest *Lepidosteus*.

So far as the writer is able to ascertain, the protocercal tail is less frequent in later geological epochs, while the obviously heterocercal form, as with *Palæoniscus*, etc., becomes more and more abundant.

Apparently, therefore, the order of succession of the three or four kinds of tails coincides, in the main, with the series seen in the grow-

ing *Lepidosteus ;* and the geological, the zoölogical, and the embryological series, upon the whole, have a recognizable correspondence.

So far, the writer has endeavored to give an outline of the natural history of the gar-pike as a peculiar American fish, concerning which little has hitherto been published even in strictly scientific works, and almost nothing in a form generally accessible.

In so doing he has purposely avoided the presentation of controversial points, or, in reference to the nomenclature of the air-bladder and of the tail, has presented opposing views, with an abstract of the evidence, so far as known to him; admitting his inability, as yet, to form a definite conclusion.

But there is another and, in some respects, most interesting and important light in which the gar-pike may be considered, namely, as to its relations with other fish-like forms.

Is *Lepidosteus* merely a somewhat peculiar fish ? Or may it, with *Polypterus* and some fossils, be separated as a distinct group ? Or should there be added to this group *Amia* and the sturgeons ? Or should the catfishes and their kindred, with the pipe-fishes, globe-fishes, and others, be likewise included ?

Upon what grounds may this group be defined ? What is its grade, class, sub-class, or order ? And how may it be subdivided ?

Attempts have been made to find answers to these questions by the study of the scales, the skeleton, the limbs, the gills, and various internal organs. The embryology of the sturgeons is not fully known, while nothing whatever has been observed of the earlier stages of the so-called typical Ganoids.

It is probably within the truth to say that, from the time of Cuvier down, no two authors upon fishes agree upon all the points, while any contemporary discussion, whether verbal or in print, is almost certain to be attended with a degree of heat quite incompatible with the apparent importance of the subject.

The fact is, however, that the so-called Ganoids occupy a very peculiar position. None of them can be touched without affecting the entire series of fish-like forms. Ichthyology is in a state of instability, and every important new fact, every decided expression of opinion by high authority respecting the Ganoids is liable to require a revision of all our ideas.

To present even an outline of the many views, and of the facts and considerations upon which they are based, would require an entire article, with many figures and some anatomical description.

To the reader who has become interested by the foregoing imperfect sketch of the gar-pike, and who has the good fortune to live within reach of it, of *Amia*, and of the sturgeons, the writer would earnestly recommend a careful and systematic investigation of their habits and their structure—especially that of the brain—and of their development, as likely to furnish the most reliable basis for their classification.

RELATION OF THE AIR TO THE HOUSE WE LIVE IN.[1]

By Dr. MAX VON PETTENKOFER,
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WE shall devote this evening to the consideration of some hygienic functions of the house.[2] On the whole, the house has the same hygienic object as our clothing: it has not only to keep up the intercourse with the atmosphere surrounding us, but to regulate it according to our wants. No more than our clothing ought the house to be a contrivance for excluding us from the air outside. In some of their forms we can also trace a certain mutual transition. The cloak and the tent are cousins. The heavy circular cloak of former times might well be styled a portable tent, and the tent a fixed cloak; both have their necessary openings. So the hat may be considered the roof of our clothing, and the roof the head-gear of the house.

We may then naturally suppose that those materials which are advantageous for the building of our habitations must stand in somewhat the same relations to air, water, and heat, as the materials we use for our clothing. Walls allow air to pass through them, and they must do so to a certain degree, if we are to preserve our health within them with some comfort, and without injury. Current opinion is certainly opposed to my assertion about the permeability of walls to air, even more so than to that about the permeability of our clothing; but it is easy to show that current opinion labors under an error which has no other basis than the insensibility of our senses to the movement of the air, if the same is less than nineteen inches per second. This is the cause of the fallacy that no motion of the air takes place. Just as well might we deny the earth's rotation round its axis at the rate of more than a quarter of a mile per second, because we are not in the least aware of this tremendous velocity. Only very late and slowly have our minds opened to the conviction that after all the earth moves round the sun, and not the sun round the earth, and that our eyes had all the while been mistaken. There must exist something of a higher nature, of a greater power, than our sensuous perceptions, and that is science, which examines and probes our perceptions. Science has not the least power over Nature; she cannot command any alteration in Nature, cannot give it any laws—

[1] Abridged and translated by Augustus Hess, M. D., member of the Royal College of Physicians, London, etc.

[2] In England, owing to the manner of building, the smaller size of the houses, the open fireplaces, and the badly-fitting windows and doors, we suffer less from defective ventilation than in Germany; and, although some other domestic arrangements, though far from faultless, are superior to those usually met with in Germany, nevertheless, the general laws are the same, and ought to be generally understood.—Translator.

she can only recognize the laws of Nature. But science changes the notions of man, and often reverses them. Ideas and notions based on science enrich us, partly directly, partly indirectly, with new means of making use of natural laws. It was not till astronomy had found and determined celestial mechanics that the human mind was enabled to begin that development of the mechanical element which is the pride and the power of our period as compared with former times.

If, then, we are hopefully satisfied with endeavoring to increase our insight, our science of the things that are, the benefit will not fail to come, and everything is beneficial of which man learns to make use. This requires time—often a very long time—as old experience teaches.

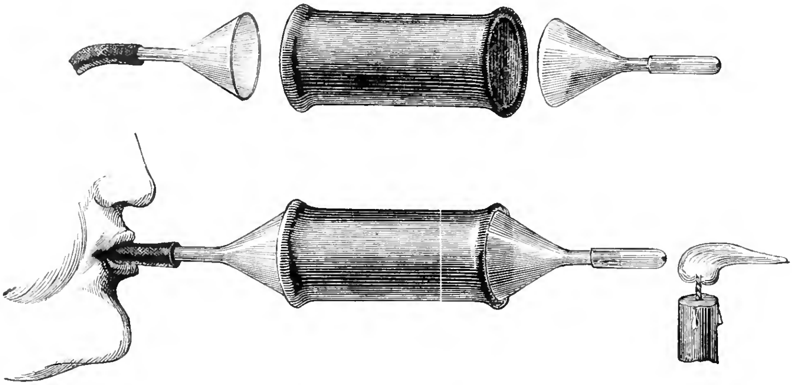
The task of science is to lay hold of everything perceptible, and to penetrate it—the small as well as the great. The insect and its life is just as interesting to science as the elephant, and therefore I believe that I may occupy myself with that air which flows through our walls, although its motion is not recognized by our sensations.

We may conclude from many facts that walls are permeable to air. No one maintains that houses have water-tight walls, and everybody knows that masonry is easily penetrated by water. Wherever a wall is in perpetual contact with water, it becomes so soaked that at last water comes out in drops on the other side. Certainly, where water can pass, air must pass much more easily, because air is seven hundred and seventy times more light and movable than water. It is very easy to construct water-tight apparatuses and vessels, but very difficult to make them air-tight. Still people are surprised when they hear of a change of the air through a wall; they see, of course, and feel the water in the wall, but of the air in it their senses have no direct perception.

But we have means to demonstrate to our senses the passage of air through our building-materials; we have only to lead the air which comes against some large surface of wall into and through a narrow tube. I will prove this to you by experiments; but you have often seen the same thing before, when you were looking at some piece of water which had some small in- and outflow. These may be in lively motion and driving mills, but on the whole surface the water seems to be completely at rest. But, if we do not see any water running in and out, we declare the whole to be stagnant, and we may be very much mistaken.

I have here a cylindrical piece of mortar, half lime, half sand, five inches by one and two-thirds. The cylinder has been covered all over with melted wax, which is inpermeable to air, with the exception of its two circular ends. You see this glass funnel, with a tube. I fix it on one circular end, where the mortar lies free, and make an air-tight connection by wax with the waxen coat of the cylinder. If I blow through the tube, the air must appear on the free mortar-end, pro-

vided the mortar is permeable to air. It has as yet no effect on the flame of this candle, because its velocity is not great enough. But if I fix a funnel on the other end of the cylinder, the air which has passed through the mortar can only escape through its narrow end, and there you see the flame sensibly deviating. You may even succeed in extinguishing it altogether. The velocity of the air in going through the tube must increase in proportion as the transverse section of the



tube is smaller than the mortar-surface, out of which the air escapes, exactly as with the water of the pond and its in- and outflow. Now, when I dip the end of one tube into water, you see and hear the air which has passed through the mortar escape from the water. If you make a similar arrangement with a piece of wood, or a brick, you will see the same result.

Most kinds, also, of sandstone are so porous that water and air easily pass through them. Solid or quarried limestones are scarcely permeable to air, but, as they are mostly of irregular shapes, they require more mortar, and that is the reason why such walls are, after all, not so much more air-tight than walls made of regular bricks and thin layers of mortar. Observations have been taken of the average quantity of mortar used with different building-stones. We may suppose that, taking the wall as a whole, it is one-third with quarried lime, one-fourth with tufaceous lime, one-fifth to one-sixth with bricks, one-sixth to one-eighth with cubes of sandstone. In practice, then, the quantity of the mortar rises with the decrease of porosity in the building-stones, and assists in keeping the walls pervious to air to a certain degree.

It is self-evident that the quantity of air which passes through building-materials of a certain thickness must increase in proportion to the surface; two square feet must give passage to twice as much air as one square foot. I shall speak of ventilation in connection with this later on.

The effect of wetting porous materials is quite surprising. In proportion as the pores fill with water, they become impervious to air. The adhesion of water to stone and mortar is greater than that of air, by as much as water is heavier than air. It is not difficult to blow great volumes of air through dry mortar and dry bricks, but it requires a great exertion to drive a few drops of water through the same materials. You know this cylinder of mortar (*see* above). Instead of blowing air through it into water, I will suck the air out of it: you see now the water rise in the tub and wet the surface of the mortar. Now I'll try to blow again air through the mortar; I cannot, with all my exertions, because the pores of the mortar are filled with water.

This simple experiment lays bare the great hygienic disadvantage of wet walls; they are air-tight, not to speak of other injurious effects.

We all know that new houses are dreaded on account of their humidity. In some countries there are regulations by law, and new houses must be approved with respect to their dryness before they may be let. But the notions about the causes of their humidity, and the means of removing it, are very different and discordant. Allow me, therefore, to explain how water gets into the new house, and how it is to be got out of it.

I need not call to your mind the first steps in a building operation, and how soon a connection is made with some abundant source of water, and that a great deal of water is required for making the mortar, etc. Let us now try to come to an estimate of this quantity of water.

Suppose that 100,000 bricks were used for a building, each weighing ten pounds. A good brick can suck up more than ten per cent. of its weight in water, but we will put down at five per cent. what gets into it by the manipulations of the bricklayer. We will assume that the same amount of water is contained in the mortar, a quantity certainly much understated, although the mortar forms only about one-fifth of the walls: we have thus 100,000 pounds of water, equal to 10,000 gallons, which must have left the walls of the house before it becomes habitable.

The two principal ways in which wet or damp walls are injurious are: 1. By impeding ventilation and diffusion of gases, through their pores being closed up or narrowed by water; 2. By disturbing the heat-economy of our bodies. Damp walls act as bodies abstracting heat in one direction; they absorb heat by their evaporation, and act like rooms which have not been warmed thoroughly; they are better conductors of heat than dry walls, just like wet garments, and considerably raise our heat-losses by a one-sided and increased radiation. Diseases which are known to be often caused by cold are particularly frequent in damp dwellings—rheumatism, catarrh, chronic Bright's disease, etc.

What can we do to get rid of that immense quantity, of these

10,000 gallons of water, before we remove into the new house? All this water—we cannot make it run off, we cannot squeeze it out, we cannot boil it away—it must take its leave in one way, a very safe but rather long one, that of spontaneous evaporation into and by the air.

The capacity of the air for receiving water depends on the different tension of the vapor at different temperatures, on the quantity of water already contained in the air flowing over a moist body, and finally on the velocity of that air. For the first two moments let us assume the average temperature of the year to be about 50° Fahr., and the average hygrometric condition of the air to be seventy-five per cent. of its full saturation. Under these conditions, one cubic foot of air can take up four grains of water, in the shape of vapor, but as it contains already seventy-five per cent. of these four grains, which amounts to three grains, it can only take up one additional grain. As often, then, as one grain is contained in the 10,000 gallons of water mentioned above, as many cubic feet of air must come in contact with the new walls, and become saturated with the water contained in them; or about 700,000,000 cubic feet of air are required to dry the building in question.

I will at once pass on to the consideration of a subject which some of you may be acquainted with already by experience—I mean the reappearance of damp in new buildings, which had seemed quite dry, after they had become inhabited. There appear damp spots on walls and in corners, the panes in the windows sweat, and the air becomes musty and oppressive. How does this water return, after the house has been declared and considered dry? Most people, because they see it only then, suppose that there is a new formation of water in the wall, or that it was set free by the presence of the new dwellers. Here, again, our sensuous perceptions mislead our judgment, and give us no clew as to the circumstances under which moisture in the walls becomes visible to our eyes and humidity produces a damp spot. I produce here a piece of brownish-yellow paper of somewhat indistinct tint. Where I wet it with water, the color appears more intense, darker even, just as if the water had been colored. Now the paper is getting dry again, and the former appearance comes back.

Some of you may laugh at me for making such a trivial experiment, but I beg to ask, What is the reason of this action of the water? It takes place only on porous colors or colored surfaces which are porous, only on *aquarelles* or frescoes, scarcely on porcelain or glass paintings. If the water cannot penetrate into the color it cannot alter its appearance any more than that of a colorless, transparent glass.

Oil-paintings, when they are new or lately varnished, are in this respect like glass-paintings, but when they get older, some of the colors, by the longer action of the air, get dull, and then water has the same effect on them as on this paper. It gives them a fresher appear-

ance till it has dried away. This is because all oil-colors become porous in the course of time.

For water to penetrate thus into the colors, we are entitled to assume that there must be free spaces within them to receive it, pores and interstices. These cannot have been *vacua* before, but must have contained air. This air in the painted surface is displaced by the water, and hence the difference in the optical effect. Air and water have different optical properties. In the first instance our colors—dry and dulled—are mixed with air; in the second instance with water. Water refracts, disperses, and reflects light quite differently from air; therefore it must have quite a different effect on colors when it gets admixed with them instead of air. The whole question has been more fully treated by me in a little treatise on oil-colors and the preservation of galleries; it may suffice here, and for the present, to know that damp spots on a wall can appear only when the pores are filled with water or some other transparent liquid. Our sensations have rightly taught us to associate the words dry and airy, damp and confined.

If we have moved into a new building too soon, we may be deceived by its appearance. It is quite possible that the walls have become sufficiently free from water and full of air for the colors of the papers and walls to appear mixed with air and free from all interstitial water; still, we are not entitled to suppose that all water has left the walls. A good deal may remain unnoticed, provided some air is lodged in the pores of the surface sufficient to produce the optical effect of real dryness.

How does it, then, happen that, on receiving their complement of inhabitants, the pores of the new walls become obstructed, partly or locally, by water? The ordinary explanation is completely erroneous, although it sounds quite scientific and rational, and has its place in books and lectures on chemistry. It is stated that it is the effect of carbonic acid on the hydrate of lime which remained in the mortar. Mortar is a very interesting object, and I regret that I cannot enter more fully into its nature and process of hardening. I'll tell you so much, that the burned and slaked lime used for its preparation is a compound of lime (oxidized calcium) and water, the above-mentioned hydrate of lime. This, by the action of the air, is changed into carbonate of lime. This change takes place at first very rapidly, and to the extent of about one-half, but then slower and slower, so that in very old masonry one finds frequently some of the original hydrate of lime. This is a perfectly dry substance, which yields none of its water to air which is dry and free from carbonic acid. When changed into carbonate of lime, the water, which as a hydrate it contained, chemically combined, is set free, while the lime and the carbonic acid combine. This water is commonly considered to produce the damp spots which appear here and there in new buildings. It has been im-

agined that the respiration of the new inmates increases the amount of carbonic acid in the air, and accelerates the process, setting free the water, which renders the wall damp and chokes up its pores.

This explanation is not based on any single direct observation made on the wall itself; it is nothing but a specious conclusion. Although hydrate of lime exposed to air which contains carbonic acid changes into carbonate of lime, no one has ever found it becoming moist. The liberation of the water, however much it may be accelerated in the indicated way, is unable to refill the pores of the wall, which were supposed to be already filled with air. To do this it would be necessary that the water in the hydrate should not have occupied any space, or that, when set free, it underwent such an expansion as water becoming a gaseous substance. All scientific analogies and observations protest against this. Changes of solid into liquid bodies take place without any considerable increase of volume; it is different with the transition of liquids into gases when the increase is very considerable.

It is only by the complete choking up of the pores by water, and the complete expulsion of the air from the surface of the wall, that the damp spots can be formed; and the freed water of the hydrate, which cannot fill a space which it had not filled while in its former combination, cannot do this. So the absorption of the carbonic acid is unable to produce the required increase of volume.

The fresh spots in new buildings can only arise from the precipitation of water from the air on the walls.

The inhabitants of a house give rise to a great amount of watery vapor, not only by the functions of their lungs and skin, but also by the numerous manipulations of the household, such as cooking, washing, cleaning, etc. If the air in the house is already saturated with water in proportion to its temperature, a small degree of cold in the wall is sufficient to produce a dew, a precipitation of water from the vapor, just as one sees it on window-panes. But the porous wall can imbibe a good deal, and in old buildings we may see the windows sweating profusely while the walls seem to remain dry. It may last a long time before a well-constructed wall or partition gives any sign. They go on condensing water till their pores are filled and all the air expelled—then, not slowly and gradually, but all at once, numerous damp spots make their appearance.

It is, therefore, clear why those youngsters of houses are so much more subject to damp spots than their brethren of more mature age. Their walls have lost just enough of the building-water to allow the air to occupy part of the pores; optically, they seem dry, but still very little water is required to choke up the pores here and there anew, and wherever this takes place the spots break out. The effect of a fire is very instructive; nothing produces damp spots so easily in a fresh building as the first fire, when doors and windows are well

closed. The heat from the fire begins by heating the places nearest to it, and a good deal of water evaporates, so that the air in the room must come nearer its point of saturation. But at a distance from the fire, the walls being colder than the air, dew falls, and, if the pores still contain great quantities of the building-water, they soon begin to overflow.

Another proof that the water chemically combined with the hydrate of lime is not able to fill the pores when it becomes liquid lies in its proportionately small quantity. A house built, let us say, with 100,000 bricks, contains, at most, about 33,000 pounds of burned lime. This cannot combine with more than about 10,000 pounds of water in becoming a hydrate. By the time the mortar is hard and set, and the building becomes inhabited, probably one-half of the lime has become a carbonate, and there remain only 5,000 pounds of water in the remaining hydrate, which is five per cent. of the whole mass of 100,000 pounds of water which got into the new building during its erection. If, then, the other ninety-five per cent. of the building-water were gone, the five per cent., or even ten per cent., remaining, or formed by the change of hydrate into carbonate of lime, would not produce the optical phenomenon of dampness.

I have dwelt somewhat longer on this subject because it is indispensable for a correct view of the function of the wall: the removal into the open air of a great part of that watery vapor which develops itself in every human household. Our walls have to swallow a good deal of that vapor as water, and to pass it on through their body that it may evaporate on their outer surface. That is the reason why localities looking to the north, or shaded from the sun, are so much damper. This appears most clearly in unheated places, chiefly at the transition from winter to spring, when it is warmer outside than inside. We are glad to have once more the windows open to let the tepid spring air gladden the cold interior; but a good deal of water will soon be seen deposited on the walls and the objects within the rooms, which has to evaporate just as from a new building.

You are now well aware of the usefulness of porous building-materials; they alone can make dry dwellings. I cannot help thinking badly of all the substitutes for wood, brick, and mortar, which have been proposed, as zinc, iron, putty, etc. Perhaps the natural functions of the mortar-wall may one day be efficiently exercised by something else; for the present it has not been done, and will not be done as easily as many so-called practical people suppose.

Let me just relate to you a case, which shows that, without a correct view of the functions of walls, an apparently excellent plan may just produce the reverse of what was intended. In the neighborhood of iron-smelting works, the slag is often used for building-purposes. This material, associated with other stones, does very well. As it exists only in very irregular shapes, it requires large masses of mortar,

and in our case this was believed to be undesirable. So it was decided to take only large regular pieces for the erection of a large workmen's dwelling, by which means the application of mortar could be reduced very much. It was a pleasure to see how quickly the building proceeded, and how much more quickly it got dry and habitable than other buildings, where irregular pieces and much mortar had been used. As soon as the workmen and their families began to live in the new building, the traces of damp began to show, and at last the house became the dampest in the whole establishment, and remained so. The thin layers or bands of mortar could not dispose well of the water which was deposited from the air in the house, and this was the worse, as the slag is not like brick and mortar, which suck the water up, but is a vitrified substance, on which water precipitates as on a window-pane.

But how are we to judge, in a given case, whether a house is sufficiently dry? No doubt, in every locality a practical experience establishes itself, founded on the knowledge of the usual material, the manner of building, and the climate. But if, as in some countries, some authority has to declare a house dry and habitable before it is to be let, there will be no end of disputes between this authority and the proprietor, because, after all, apart from the age of the building, the verdict of the experts will be given on their subjective view, not on definite and palpable signs. You know, already, that the absence of damp spots means very little. Feeling by the hand the temperature of the walls, knocking at them with a little hammer, are all of not much good. Not a bad plan is to get from different places in the house small pieces of mortar, and to have them examined as to their contents of evaporable water, which ought not to be more than five per cent. of the weight. But we may have fallen just on dry places only, and get considerably deceived. Direct and comparative hygrometric observations would be best, but the necessary preliminary researches for this kind of examination are still to be made.

But what is to be done if a new building is to be brought quickly and surely into a condition of dryness? I have been obliged to shake your belief in the one means which appeared to exist, the development of carbonic acid by burning charcoal in basins or open stoves. But I shall try to give you something in exchange for what I have taken from you. This something is nothing but an appeal to what we have learned above. There are no means of removing the water from a fresh building but by letting it evaporate into the air. This evaporation, you know, depends on the temperature, the humidity of the air, and its velocity.

Imagine to yourselves a moderately-sized room of 3,530 cubic feet, and the temperature and humidity of the air at the above given mean averages. As one cubic foot of such air is capable of taking up one additional grain of water, the air of the whole room will take up 3,530

grains, or about half a pound, of water. Should there be no change of the air, matters would remain so. But by every fresh 3,530 feet of air coming into the room another half-pound of water would be taken up, and so on. Suppose the change amounts to 353 cubic feet per hour: all the moisture we get rid of per hour would be only 353 grains per hour. But if we heat the room to 68° Fahr., for instance, we increase the tension of the vapor, i. e., the capacity of the air for taking up water, from four to seven grains per cubic foot, so that each cubic foot of fresh air entering the room is capable of taking up seven instead of four that means four grains in addition to its original humidity; In consequence of this increased capacity, the 353 cubic feet of air take up 1,412 instead of 353 grains of water. But by the increased difference of temperature between the room and the open air, ventilation rises from 353 to 2,100 cubic feet per hour, and in this way we get rid of more than twenty times as much water as if we left the room unheated.

All kinds of stoves and charcoal-dishes act only as sources of heat, and not as sources of carbonic acid. The only rational and efficient way is the *heating of all the chimneys and stoves, and the continual ventilation of all the rooms.* All other ways are of no use, or deceptive.

You have seen that the wall has its physiology, a life of its own. Perhaps you will no longer find it so strange that Master Quince introduces not only a pale moonshine and a rough lion, but also a "sweet and lovely wall" as a living and talking person. I had many things more to tell you about the wall, but I have still another subject of special importance before me—the change of the air in the house, or ventilation.

We have seen already, in speaking of our clothes, that the well-being of our body requires a continuous current of air to flow round us, and for the same reason a flow of air must take place continually from the open air through our dwellings. It used to be a current belief that in the still air of our houses we were separated and shut off from the external air. You know that this error arises from our nerves and senses believing the air to be quite calm and motionless, although there may be some movement. We must be thankful to our Creator for this our error, else we should probably have ceased to exist. However anxious we may have been to shut ourselves up from the external air, we still remain in connection and intercourse with it. No house can have an atmosphere of its own; it has that by which it is surrounded, which travels and flows through it slower or quicker, while the house, and whatever exists and goes on in it, have no other power than to render this air more or less impure.

This pollution must not overstep a certain line, and this line depends on the proportion between the pollution and the change and volume of the air-current.

We change and pollute the air within our houses in two ways: 1. By admixture of substances which were not in the air when it came to us; and, 2. By changing its normal composition. Both are unavoidable, but there are limits, which must not be overstepped. The impurities may be in the nature of gases, or dust. We often become aware of them by our senses, by sight, by taste, mostly by smell. The last sense is exceedingly sensitive for many substances; for instance, traces of ethereal oils. Nothing is more wonderful than its acuteness with some savages and animals. If we consider the minuteness of the substances left by hunted game on the soil, which it scarcely touches in its flight, and how the dog detects them even a long time after, we cannot sufficiently admire such a performance of the sense of smell. Other substances make themselves known in other ways, sometimes by some physiological effect. Oxide of carbon, for instance—a gas which is generated from burning charcoal—is not perceived by any of our senses, but if it is present in air to the extent of a half per cent. only, it destroys human life after a while. A few grains of veratria, rubbed down into a powder, will set all the persons in the room sneezing. Other substances, as the products of distillation of fats, or the smoke of wood, irritate the membranes of the eyes. Other vapors and kinds of dust act on the taste; for instance, aloe-powder.

We rightly consider all air, which acts on our senses or our feelings differently from air in the open, to be polluted.

The second way in which we render the air impure on its journey through our houses is that of altering the quantities of its components. We deprive it of oxygen by our respiration, by the burning of lights and fires; we increase its carbonic acid and its water by the activity of our lungs and skin, and by numerous proceedings of the household.

All these pollutions and alterations are partly avoidable, partly unavoidable. Among the latter are those by our lungs and skin, because we cannot live without producing them. To the former belongs everything that from want of cleanliness, careless treatment of waste and refuse, passes into the air-current, the utilization of which ought to be the privilege of our skin and lungs. It is an inexcusable waste of ventilation, if it is directed against avoidable pollutions of the air, besides its being generally of not much use for this purpose. If I had a nuisance in my room, I should be a fool if I kept it there and trusted to stronger ventilation. The rational way is to do away with the pollutions, not to keep them and to fight them by ventilation. Without strict cleanliness in a house or public institution, all contrivances for ventilation will not do much good; the proper domain of ventilation begins where cleanliness, by rapid removal or careful shutting up of air-polluting substances, has done its best. It is only against the deterioration of the air by respiration and perspiration, which is beyond

the control of cleanliness, that ventilation can direct its power, and against this deterioration this power must be chiefly directed.

Let us now consider the different causes of the motion of the air. As air in motion is wind (*ventus*, Latin), ventilation is a better expression than "airing." Anything which disturbs the equilibrium of a body of air, produces motion in it. Its immobility supposes equality of temperature and specific gravity, and also of mixture in quantity and quality. Such conditions, as you may suppose, are seldom present, and absolute calmness is impossible. Different kinds of gases tend to intermix in every direction, even contrary to their specific weight, a process which is called diffusion; but this kind of motion is not in question when we speak of ventilation. Ventilation means the setting in motion of masses of air by mechanical pressure and the dislodging of whole bodies of air similarly composed, which, for that reason, are not subject to diffusion.

We produce ventilation by disturbing the equilibrium of the air in two ways: 1. By producing differences of temperature between two neighboring bodies of air, which are accessible to each other; 2. By mechanical pressure on or driving off the air in a certain direction. We cause the same motion in either way, but the first we call *draught*, the second *wind;* we call forth a draught by a chimney, we produce a wind by a fan, a fan-wheel, etc.

These two factors of change of the air are continually active in our houses, but to a very different extent at different times. Our houses stand in the open air, which is never quite calm; even if it appears so, there is still some imperceptible motion, some wind disposable for ventilation. Then our houses are either colder or warmer than the surrounding air. They act just like large chimneys. If they are colder, the air which comes in contact with them gets colder, and a downward air-current is produced; if they are warmer, the air gets warmer, and an ascending current is established.

It is evident that the intensity of the change must also depend on the way in which the house is shut up, on the size and number of its apertures, and the porosity of the materials it is built with.

For this reason a certain amount of ventilation is always taking place wthout any special arrangement for it, but its strength depends —1. On the amount of difference of temperature between outside and inside; 2. On the strength of the wind or air-motion in the open; 3. On the size of the apertures which are open to the change of the air. We may call the first two the air-motors, the last the air-mediator or janitor, door-keeper; to a certain degree, they can take each other's place. If there is not enough difference of temperature, as, for instance, in summer, the wind can act; if both together are too weak, opened doors and windows can help. In winter, when the difference of temperature between the in- and out-door air is considerable, small openings allow the passage of as much air as large open-

ings during summer, because the difference of pressure is greater. When, in winter, we stay in an unheated room, whose temperature is only slightly above that of the outer air, ventilation is quite as weak as in summer; the air, if the windows remain closed, becomes quite as bad by our presence, and we ought to air the room as in summer; but we do not, because we want to protect ourselves against the outside cold. The dwellings of the lower classes present frequently, during the greater part of winter, this form of defective ventilation, which gets worse with the length of the cold season. In the beginning the walls are still dry and porous, and assist the ventilation, so far as the wind helps them to do so; but in proportion as they get colder, they increasingly condense water from the air of the house, and finally become so choked up with it that they allow no air to pass, as you have seen in our moistened piece of mortar. Bad doors and windows, unmended window-panes, remain often the only routes of ventilation. Poor people, in complaining of them, are not aware that they are the smaller of many evils, and a defect without which they might suffer still more.

Many of you, on hearing this, may be gratified by an unexpected personal satisfaction. Those who try to alleviate the poor man's winter by gifts of fuel not only procure for him the benefit of a warm room, but also of a better and purer air in this room. You may consider this as a scientific parable, showing that in each benevolent action there lies a further blessing, even if we had not intended it.

It follows, from these fundamental principles of ventilation, that a great mistake is sometimes made in large dormitories. In the morning the custom is to open the windows, and to let them remain open all day long, to be closed only just before bedtime. The poor sleepers fancy that they are sleeping all night in a pure air. Whoever has occasion to enter such a place in the morning, before rising-hour, starts back before this "pure air," which had only been renewed during the night partially and accidentally, and is so loaded with all kinds of animal emanations that it presses with all its power on the fresh comer. If there is no sufficient difference of temperature between outside and inside, a partial opening of the windows during a winter night is just as necessary as during a summer night, as far as regards the change of the air.

The bodies of the sleepers are certainly a small source of heat, and such large sleeping-places become somewhat warmed by the human heat flowing from the beds, but they can never be warmed through and through, so that the walls could become warmer. The water-vapor exhaled by the sleepers condenses against the walls, and goes on obstructing their pores till morning. A part of this water may evaporate during the time that the windows are kept open, but it will be only a part, and hence the frequent breaking out of damp spots in such dormitories in the course of the winter.

There was a belief that sleeping in the cold was a good thing; but I cannot find any facts proving this theory, particularly no comparative observations about the wholesomeness of heated and unheated dormitories. It would be safer to say that experience proves that sleeping in the cold does not, generally, do harm. If a single person sleeps in a large cold room with shut doors and windows, it will do him no harm when he has a good bed. One person cannot deteriorate the air of an unventilated space as much as two or more. The bed is a garment, an apparatus, which is of great use for our heat-economy; it prevents our feeling cold even in the coldest dormitory, but the bed is no ventilating apparatus, and ventilation must be provided for in another way. He that wants to sleep safely in the cold must have a good bed and a large space, or bad windows and doors, or very porous walls, or he must keep his windows partly open in winter as well as in summer.

You have probably now the desire to hear from me how much air or ventilation a person wants in a stated time. After you have all the while heard from me that everything is full of air, that air penetrates everywhere, and that it is extremely difficult to prevent its passage, many among you will ask: "What need is there of special contrivances, if the air passes through each brick, through mortar, through wood? Would it not be rather desirable to protect ourselves against this universal aggression of the air?"

It is with air as with all things which we must have—as with money, of which we must not only have some, but sufficient—one must have as much as one requires. Some money is, after all, in everybody's possession, even that of the poorest beggar.

Till some time ago, ventilation was chiefly considered in its qualitative aspect: we wanted change of the air, and were satisfied if there was one aperture for it to go out, and another to come in. The question about the quantity of this air was never put; if it had been known how much was really wanted, and how it was to be procured, that amount of ventilation which was often paraded would have appeared beggarly. It is only during the last twenty years that we have acquired clear ideas on this subject.

We deteriorate the air of a closed space inevitably by using it for the maintenance of our respiration and perspiration. To which degree, then, may we alter or pollute by our emanations the air of a closed space, without going so far as to injure our health? This leads us to another preliminary question: What standard have we for measuring the deterioration of the air?

At all times people have been in the habit of making some estimate of the pollution of the air by the smell imparted to it by the respiration and emanations of the persons staying in it. This estimate is of the same value as that we have spoken of when on the subject of the water in the walls. The smell of a certain air need not be in any kind

of proportion to the use which has been made of it already for the purposes of respiration and evaporation. Besides, smelling is a very subjective sensation, of very different excitability in different persons. Although generally a certain rule for judging the air of a room may be based on its smell, the decision, in doubtful cases, will always be a subjective one. It would be a different thing if we could lay hold of the smelling particles in the air of the room, and measure or weigh them, and compare them with the volume of air they were taken from; but we have no method of doing this; everything is left to our noses.

For this reason I considered it indispensable to look about for some means which would make us independent of our subjective estimate. I started from the excretion of carbonic acid, as it takes place from the living human body; its quantity in the air can be ascertained easily and accurately. There is some in the open air, although very little; the question was, therefore, to find out its increase in a number of inhabited rooms, with notoriously good and notoriously bad air, and to draw a comparison. The correctness of this proceeding depends on the supposition that there are no other sources of carbonic acid but the inmates, that there are no burning flames, or tobacco-smoking, etc. I will not say that I consider the detected carbonic acid as the principal drawback to such air; it is, in my mind, the measure only for all the other alterations which take place in the air simultaneously and proportionately, in consequence of respiration and perspiration; its increase shows to what degree the existing air has been already in the lungs of the persons present. All other functions in which the air participates keep in some proportion to the respiration.

A series of examinations have resulted in the conviction that one volume of carbonic acid in 1,000 volumes of room-air indicates the limits which divide good from bad air. This is now generally adopted and practically proved, always provided that man is the only source of carbonic acid in the space in question.

Suppose there is a known source of carbonic acid: the determining the amount of it in a room can also be used for measuring another element, which would otherwise defy calculation—I mean the amount of ventilation of a closed space of definite construction. Imagine to yourselves a room with its walls, windows, and doors, its numberless penetrable places through which the air holds ingress and egress. It is impossible to measure the velocity of the air at each crack, to measure each little hole, the diameter of each pore, even if one had the means of measuring such minute velocities and sections; yet still we should like to know how much air changes in a given space, and under different external circumstances. The only way appeared to me to be to mix the air of the room in question with carbonic acid to a certain degree, then to break off this mixing, and to observe the decrease of the acid in proportion to the air in definite times. Knowing the

amount of the acid in the external atmosphere, we can calculate how much of the latter must go on mixing itself with the room-air, to which carbonic acid has been added, in order that the proportion of the acid may decrease by so and so much in a definite time. The action of diffusion or absorption may generally be left out of consideration in this calculation. I do not consider this method to be absolutely correct, but I have found it quite satisfactory when a building was a few years old, and quite dry. At all events, until a better method has been found, we must keep to this one, even if it were still less complete than it is.

By researches which are too complicated to be explained in a popular lecture, it has been found that the ventilation of the same room or space, when the doors and windows are shut, undergoes considerable and definite alterations under different circumstances. Ventilation has been found to be much greater than had been supposed before. On an average, in spaces in which the air kept good, there existed a ventilation of more than 2,100 cubic feet per head and hour. It is known that a person does not inhale and exhale more than eighteen cubic feet of air per hour, and so it was thought that 2,100 cubic feet per hour was a ridiculously large quantity for one person.

But it has been shown, first in France, not by calculation, but quite empirically by simple experimenting, that this quantity of ventilation is not more than is absolutely indispensable. After the epidemic of cholera of 1848, the erection of a model hospital in the Faubourg Poissonnière was decided upon, and the Hôpital la Riboisière was erected, which was to be furnished with artificial ventilation. The quantity of air which was required from the ventilating apparatus was stated in the plan. It was believed that the demands put under Nos. 4, 5, and 7, of the plan for ventilation, were extraordinarily large:

4. Continuous ventilation of warm air in winter and cold air in summer at least 700 cubic feet per hour and bed in the large wards.

5. Ventilation during the day only at 350 cubic feet per bed in the rooms of the corresponding pavilion.

7. The ventilating apparatus must have a surplus of strength, in order to be able to produce in all or some wards a ventilation double that stated.

The air was partly propelled by fan-wheels, partly by ventilating-flues. It flowed to and fro through pipes in the wards, and its velocity could be measured easily by anemometers.

In preliminary experiments, a ventilation of 350 cubic feet per bed and hour was tried, but the air was found already by the smell to be so bad that the authorities congratulated themselves in having provided for double the strength. This was now tried, but with the same result, and it was a comfort to know that, for extraordinary cases, another 700 cubic feet per bed and hour could be obtained; but

then also the state of the air was anything but desirable. It was only with 2,120 cubic feet that the medical and other authorities found themselves satisfied.

At present the demands for ventilation in France sound very different from what they were about twenty years ago. They are now per hour and person:

Hospitals for ordinary cases	2,120—2,470	cubic feet.
" wounded	3,530	"
" epidemics	5,300	"
Prisons	1,766	"
Workshops, ordinary	2,120	"
" unhealthy	3,530	"
Barracks, day	1,060	"
" night	1,410—1,765	"
Theatres	" "	"
Large rooms for long meetings	2,120	"
" " shorter "	1,060	"
Schools for children	424— 530	"
" adults	880—1,060	"

Such are the changes of times.

Now the many crevices, holes, and pores in our dwellings will no longer be considered by you as unlimited means of change of the air, since you know how large that change has to be; you will rather feel anxious whence to procure such enormous quantities when you sit quietly within your four walls where you do not feel the least draught, where no curtain moves, and a feather lies quietly on the floor. This sensation of calm we owe to the insensibility of our nerves—*and yet the air moves.*

In order to give you some idea of the influences of differences of temperature of more or less well-shutting doors and windows, of a fire in a stove opening into the room, and of the partial opening of a window, I will give you shortly the results I obtained with the aid of the carbonic-acid measurement. The room had brick walls, and its size was 2,650 cubic feet.

With a difference of temperature of 34° Fahr. (66° in- and 32° outside), the contents of the room changed once in one hour, equal to 2,650 cubic feet.

With the same difference, but a good fire in the stove, whose communication with the chimney was made as free as possible, the change of the air rose to 3,320 cubic feet, or about twenty-five per cent. When all openings, crevices in windows and doors, were thoroughly pasted up, there was still a change of 1,060 cubic feet per hour, or a fall of twenty-eight per cent. With a difference of temperature of 71° in- and 64° outside, the change amounted to 780 cubic feet only per hour. When opening a window of eight square feet, the change rose to 1,060 cubic feet per hour. These quantities are instructive. They show that a difference of temperature of 34° with carefully-shut openings

and crevices is of greater influence than large communications with the outer air at a small difference of temperature.

The roaring fire and the draught of the stove produced only an increase of 700 cubic feet—one-third only of the necessary ventilation per head. I have examined a number of stoves opening into the room for the quantity of air which they abstract while the fire burns. The anemometer showed that it was never more than 3,105 cubic feet. Large wards in hospitals, schools, etc., heated by one open fireplace or stove, are sometimes wrongly believed to be well ventilated, because one perceives the air rushing into the same. But the main point is to know the quantity of required air and the quantity of outgoing air.

The free wall of a room of mine has been examined for its ventilating power. The room contained 2,650 cubic feet, and at 9.5° Fahr. difference of temperature between outside and inside, the spontaneous ventilation through each square yard amounted to about seven cubic feet, or forty-three gallons per hour.

Märker and Schultze, in their researches on the spontaneous ventilation of stables, have found for one square yard of a free wall, at 9.5° Fahr. difference of temperature, that the spontaneous ventilation amounted per hour—

With	walls of	sandstone	to	4.7	cubic	feet.
"	"	quarried limestone	"	6.5	"	"
"	"	brick	"	7.9	"	"
"	"	tufaceous limestone	"	10.1	"	"
"	"	mud	"	14.4	"	"

Domestic animals, according to Märker, require a proportionately smaller change of the air than man. Stable-air may contain up to three per mil. carbonic acid. While man's ventilation requires 2,100 cubic feet per hour, 1,050 are sufficient for full-grown cattle, although their bodies and consumption of air are so much larger. The ventilation of stables depends chiefly on the size and porosity of their free walls. It has been found that the 1,050 cubic feet mentioned above were furnished by—

21.16	square	feet	of a free	wall of	sandstone.
15.33	"	"	"	"	quarried limestone.
12.6	"	"	"	"	brick.
9.7	"	"	"	"	tufaceous limestone.
7	"	"	"	"	mud.

A stable built up of mud can therefore shelter many more animals than one built of sandstone, etc. "As the strength of the natural ventilation of a stable does not depend on the cubic space of the stable, but on the extent of its ventilating walls, it follows that in a small stable a proportionately greater ventilation takes place than in a greater one, because for each animal there is more ventilating surface with equal cubic space."

This proposition naturally applies also to human habitations. The air will be better in a small family house than in large barracks; better in a cellular than in a common prison, where the day and night wards are large but crowded.

The question arises, "What is to be done in all cases in which the natural ventilation of the inhabited spaces proves insufficient, and allows the carbonic acid to become more than one per 1,000?" I might tell you now of the different systems of ventilation, the contrivances and apparatus belonging to them; but this is not feasible without models and designs. And, after all, there would be no new principles or natural laws to acquaint you with. I believe I have made you sufficiently aware of the fundamental facts and conditions as to the change of the air in our dwellings, so far even that you are now able to judge for yourselves whether a certain plan for ventilation is rational or not. We have no other motors for changing the air, but differences of temperature and motion of the air, which we can call forth either by heat or by the motion of wind-fans—or which we must make use of as far as they are preëxisting in the atmosphere surrounding the house. By these two means we can produce certain perturbations in the equilibrium of the air-columns, and through this certain degrees of velocity in the motion of the air.

If we know the transverse section of the inlets and outlets, we have only to multiply their surface by the velocity of the air, and this will give the cubic quantity of the air which flows through the channels in a certain time. If we know the required quantity of air and divide it by the transverse section of the channels, we get at the velocity of the air in the channels. We ought not to establish a greater velocity than nine feet per second; it is better to enlarge the channels. These quantities must then be compared with the air required by each person, a quantity with which you are now acquainted.

If you take up the question of artificial ventilation in its quantitative aspect, you protect yourself at once against a series of errors into which else you easily fall. Our ordinary dwelling-houses need not be ventilated artificially; we ought never so to crowd them that the natural means of ventilation, as difference of temperature, motion of the air in the open, dry and porous walls, and temporary assistance by the architectural openings, are insufficient to keep undeteriorated what is most essential for our health. With these means there must go hand-in-hand the greatest cleanliness in all parts of the house, and abstention from all superfluous and avoidable pollution of the air of the house.

Before concluding, I am desirous of considering with you an expression which is in general use, but the frequent cause of wrong views about the change of the air. I mean the word *draught*. All kinds of complaints are habitually ascribed to it, and the danger of

draughts is one of the few hygienic principles which have become thoroughly popular. Perhaps this was not all profit, because with many people ventilation and draught are synonymous; they are afraid of a draught coming from an open window, an open door, and find themselves in collision with ventilation.

There is certainly and frequently danger in being exposed to a draught—a danger which has, perhaps, been over-estimated, because men have an irresistible desire to fix a certain cause for a certain evil. All collision is avoided if the proper meanings of *ventilation* and *draught* are thoroughly understood.

Ventilation is the necessary change of the air in a closed space, at which the velocity of the air is still taken for a complete stillness, and its motion takes place all round our body. It must not be more than a little above nineteen inches per second.

Draught is a one-sided cooling of the body, or some part of it, frequently caused by a corresponding motion of cold air, but also in other ways, as by increased one-sided radiation. The danger is, in the first instance, the local perturbation in our heat-economy, which has partly local consequences, but also and chiefly disorders the nerves, acting on the calibre of our blood-vessels, our vaso-motor nerves, which have to regulate the outflow of our heat. When we are in the open, and the air is in more motion than the air of a draught, we speak of wind, etc., but seldom of draught, because the whole air-current flows equally all round us, just as in a well-ventilated room, only with greater velocity.

The vaso-motor nerves, regulating the circulation in our skin, are beyond our control, and we cannot bid them to defend us simply at the place attacked by the draught. They know only how to serve our heat-economy when the outflow of heat from our bodies is equal, or nearly so, on all sides. They misunderstand the local irritation for one spread over the whole surface, and act at once on this error. If one perspires and goes to the window with bared neck or chest, one feels a shiver not only there but all over the body, and the perspiration becomes suppressed accordingly. The blood which at the time filled the blood-vessels of the glowing skin is displaced by the contraction of its channels; but by the misunderstanding of the vaso-motor nerves it is driven not only from the exposed parts but from the whole surface toward the internal parts. If one or some of them are in some state of weakness, danger or bad consequences cannot fail. It is the same thing as with a large quantity of cold water taken in too quickly when the body is heated. A draught, then, is injurious only in so far as it causes perturbations in our heat-economy, and as these perturbations can be caused in different ways we often accuse the draught wrongly.

We hear often, "I don't like sitting near this window, close to this wall," and so on; "there is always a slight draught coming from

there." We fancy that we feel the draught, the motion of a wind, but it is mostly increase of one-sided heat-loss by radiation toward the cold place. People generally believe, rather, that the wind comes through the wall. But the velocity of such a wind is too small to be felt as air in *motion*, and a piece of carpet fixed to the suspected wall does away with the supposed draught. It could, therefore, not be caused by the air-rush through the wall, because the carpet is many times more permeable to air than the wall.

I hope, in future, ventilation and draught will be to your mind two distinct things.

SPINOZA: 1677 AND 1877.[1]

By ERNEST RENAN.

ON this day two hundred years, in the afternoon, and at about this same hour, there lay dying, at the age of forty-three, on the quiet quay of the Pavilioengragt a few paces hence, a poor man, whose life had been so profoundly silent that his last sigh was scarcely heard. He had occupied a retired room in the house of a worthy pair, who, without understanding him, felt for him an instinctive veneration. On the morning of his last day he had gone down as usual to join his hosts; there had been religious services that morning; the gentle philosopher conversed with the good folk about what the minister had said, much approved it, and advised them to conform themselves thereto. The host and hostess (let us name them; their honest sincerity entitles them to a place in this beautiful Idyl of the Hague related by Colerus), the Van der Spycks, husband and wife, went back to their devotions. On their return home, their peaceful lodger was dead. The funeral, on the 25th of February, was conducted like that of a Christian believer, in the new church on the Spuy. All the inhabitants of the district greatly regretted the disappearance of the sage who had lived among them as one of themselves. His hosts preserved his memory like a religion, and none who had approached him ever spoke of him without calling him, according to custom, "the blessed Spinoza."

About the same time, however, any one able to track the current of opinion setting in among the professedly enlightened circles of the Pharisaism of that day, would have seen, in singular contrast, the much-loved philosopher of the simple and single-hearted become the bugbear of the narrow orthodoxy which pretended to a monopoly of the truth. A wretch, a pestilence, an imp of hell, the most wicked atheist that ever lived, a man steeped in crime—this was what the

[1] Address delivered at the unveiling of the monument at the Hague, February 21, 1877.

solitary of the Pavilioengragt grew to be in the opinion of right-thinking theologians and philosophers!

Portraits were spread abroad exhibiting him as "bearing on his face the signs of reprobation." A distinguished philosopher, bold as he, but less consistent and less completely sincere, called him "a wretch." But Justice was to have her day. The human mind, attaining, in Germany especially, toward the end of the eighteenth century, to a more enlightened theology and a wider philosophy, recognized in Spinoza the precursor of a new gospel. Jacobi took the public into his confidence as to a conversation he had held with Lessing. He had gone to Lessing in hopes of enlisting his aid against Spinoza. What was his astonishment on finding in Lessing an avowed Spinozist! "Ἓν καὶ πᾶν," said Lessing to him—this is the whole of philosophy. Him whom a whole century had declared an atheist, Novalis pronounced a "God-intoxicated man." His forgotten works were published, and eagerly sought after. Schleiermacher, Goethe, Hegel, Schelling, all with one voice proclaim Spinoza the father of modern thought. Perhaps there may have been some exaggeration in this first outburst of tardy reparation; but time, which sets everything in its place, has substantially ratified Lessing's judgment; and in the present day there is no enlightened mind that does not acknowledge Spinoza as the man who possessed the highest God-consciousness of his day. It is this conviction that has made you decree that his pure and lowly tomb should have its anniversary. It is the common assertion of a free faith in the Infinite that on this day gathers together, in the spot that witnessed so much virtue, the most select assembly that a man of genius could group round him after his death. A sovereign, as distinguished by intellectual as by moral gifts, is among us in spirit. A prince who can justly appreciate merit of every kind, by distinguishing this solemnity with his presence, desires to testify that, of the glories of Holland, not one is alien to him, and that no lofty thinking escapes his enlightened judgment and his philosophic admiration.

I.

The illustrious Baruch de Spinoza was born at Amsterdam at the time when your republic was attaining its highest degree of glory and power. He belonged to that great race which, by the influence it has exerted and the services it has rendered, occupies so exceptional a place in the history of civilization. Miraculous in its own way, the development of the Jewish people ranks side by side with that other miracle—the development of the Greek mind; for if Greece, from the first, realized the ideal of poetry, of science, of philosophy, of art, of profane life, if I may so speak, the Jewish people has made the religion of humanity. Its prophets inaugurated in the world the idea of righteousness, the revindication of the rights of the weak—a revindication so much the more violent that, all idea of future recom-

pense being unknown to them, they dreamed of the realization of the ideal upon this earth, and at no distant period. It was a Jew, Isaiah, who, seven hundred and fifty years before Jesus Christ, dared affirm that sacrifices are of little importance, and that one thing only is needful: purity of heart and hands. Then, when earthly events seemed irremediably to contradict such bright Utopias, Israel can change front in a way unparalleled.

Transporting into the domain of pure idealism that kingdom of God with which earth proves incompatible, one moiety of its children founds Christianity, the other carries on, through the tortures of the middle ages, that imperturbable protest: "Hear, O Israel! the Lord thy God is one; holy is his name." This potent tradition of idealism and hope against all hope—this religion, able to obtain from its adherents the most heroic sacrifices, though it be not of its essence to promise them any certainty beyond this life—this was the healthy and bracing medium in which Spinoza developed himself. His education was at first entirely Hebraic; the great literature of Israel was his earliest, and, in point of fact, his perpetual instructress—was the meditation of all his life.

As generally happens, Hebrew literature, in assuming the character of a sacred book, had become the subject of a conventional exegesis, much less intent upon explaining the old texts according to the meaning in their authors' minds than on finding in them aliment for the moral and religious wants of the day. The penetrating mind of the young Spinoza soon discerned all the defects of the exegesis of the synagogue; the Bible, as taught him, was disfigured by the accumulated perversions of more than 2,000 years. He determined to pierce beyond these. He was, indeed, essentially at one with the true fathers of Judaism, and especially with that great Maimonides, who found a way of introducing into Judaism the most daring speculations of philosophy. He foresaw with wondrous sagacity the great results of the critical exegesis destined, 125 years later, to afford the true meaning of the noblest productions of Hebrew genius. Was this to destroy the Bible? Has that admirable literature lost by being understood in its real aspect rather than relegated outside of the common laws of humanity? Certainly not. The truths revealed by science invariably surpass the dreams that science dispels. The world of Laplace exceeds in beauty, I imagine, that of a Cosmas Indicopleustes, who pictured the universe to himself as a casket, on the lid of which the stars glide along in grooves at a few leagues from us. In the same way, the Bible is more beautiful when we have learned to see therein—ranged in order on a canvas of a thousand years—each aspiration, each sigh, each prayer of the most exalted religious consciousness that ever existed, than when we force ourselves to view it as a book unlike any other, composed, preserved, interpreted in direct opposition to all the ordinary rules of the human intellect.

But the persecutions of the middle ages had produced on Judaism the usual effect of all persecution: they had rendered minds narrow and timid. A few years previously, at Amsterdam, the unfortunate Uriel Acosta had cruelly expiated certain doubts that fanaticism finds as culpable as avowed incredulity. The boldness of the young Spinoza was still worse received; he was anathematized, and had to submit to an excommunication that he had not courted. A very old history this! Religious communions, beneficent cradles of so much earnestness and so much virtue, do not allow of any refusal to be shut up exclusively within their embrace; they claim to imprison forever the life that had its beginnings within them; they brand as apostasy the lawful emancipation of the mind that seeks to take its flight alone. It is as though the egg should reproach, as ungrateful, the bird that had escaped therefrom. The egg was necessary in its time; when it became a bondage, it had to be broken. A great marvel, truly, that Erasmus of Rotterdam should feel himself cramped in his cell; that Luther should not prefer his monkish vows to that far holier vow which man, by the very fact of his being, contracts with truth! Had Erasmus persisted in his monastic routine, or Luther gone on distributing indulgences, they would have been apostates indeed! Spinoza was the greatest of modern Jews, and Judaism exiled him. Nothing more simple; it must have been so, it must be so ever. Finite symbols, prisons of the infinite spirit, will eternally protest against the effort of idealism to enlarge them. The spirit, on its side, struggles eternally for more air and more light. Eighteen hundred and fifty years ago the synagogue denounced as a seducer the one who was to raise the maxims of the synagogue to unequaled glory. And the Christian Church, how often has she not driven from her breast those who should have been her chiefest honor! In cases like these, our duty is fulfilled if we retain a pious memory of the education our childhood received. Let the old Churches be free to brand with criminality those who quit them; they shall not succeed in obtaining from us any but grateful feelings, since, after all, the harm they are able to do us is as nothing compared to the good they have done.

II.

Here, then, we have the excommunicated of the synagogue of Amsterdam forced to create for himself a spiritual abode outside of the home which rejected him. He had great sympathy with Christianity, but he dreaded all chains; he did not embrace it. Descartes had just renewed philosophy by his firm and sober rationalism. Descartes was his master. Spinoza took up the problems where they had been left by that great mind, but saw that, through fear of the Sorbonne, his theology had always remained somewhat arid. Oldenburg asking him one day what fault he could find with the philosophy of Descartes and of Bacon, Spinoza replied that their chief fault lay in

not sufficiently occupying themselves with the First Cause. Perhaps his reminiscences of Jewish theology, that ancient wisdom of the Hebrews before which he often bows, suggested to him higher views and more sublime aspirations in this matter. Not only the ideas held by the vulgar, but those even of thinkers on Divinity, appeared to him inadequate. He saw plainly that there is no assigning a limited part to the Infinite; that Divinity is all, or is nothing; that if the Divine be a reality, it must pervade all. For twenty years he meditated on these problems without for a moment averting his thoughts. Our distaste nowadays for system and abstract formula no longer permits us to accept absolutely the propositions within which he had thought to confine the secrets of the Infinite. For Spinoza, as for Descartes, the universe was only extension and thought; chemistry and physiology were lacking to that great school, which was too exclusively geometrical and mechanical. A stranger to the idea of life, and those notions as to the constitution of bodies that chemistry was destined to reveal—too much attached still to the scholastic expressions of substance and attribute—Spinoza did not attain to that living and fertile Infinite shown us by the science of Nature and of history as presiding in space unbounded, over a development more and more intense; but, making allowance for a certain dryness in expression, what grandeur there is in that inflexible geometrical deduction leading up to the supreme proposition, "It is of the nature of the Substance to develop itself necessarily by an infinity of infinite attributes infinitely modified!" God is thus absolute thought, universal consciousness. The ideal exists, nay, it is the true existence; all else is mere appearance and frivolity. Bodies and souls are mere modes of which God is the substance: it is only the modes that fall within duration; the substance is all in eternity. Thus, God does not prove himself; his existence results from his sole idea; everything supposes and contains him. God is the condition of all existence, all thought. If God did not exist, thought would be able to conceive more than Nature could furnish—which is a contradiction.

Spinoza did not clearly discern universal progress; the world, as he conceives it, seems as it were crystallized in a matter which is incorruptible extension, in a soul that is immutable thought; the sentiment of God deprives him of the sentiment of man; forever face to face with the Infinite, he did not sufficiently perceive what of the Divine conceals itself in relative manifestations; but he, better than any other, saw the eternal identity which constitutes the basis of all transitory evolutions. Whatever is limited seems to him frivolous, and unworthy to occupy a philosopher. Bold in flight, he soared straight to the lofty, snow-covered summits, without casting a glance on the rich display of life springing up on the mountain's side. At an altitude where every breast but his own pants hard, he lives, he enjoys, he flourishes there, as men in general do in mild and temper-

ate regions. What he for his part needs is the glacier-air, keen and penetrating. He does not ask to be followed; he is like Moses, to whom secrets unknown to the crowd reveal themselves on the heights. But be sure of this: he was the seer of his age; he was in his own day the one who saw deepest into God.

III.

It might have been supposed that, all alone on those snowy peaks, he would turn out in human affairs wrong-headed, utopian, or scornfully skeptical. Nothing of the kind. He was incessantly occupied with the application of his principles to human society. The pessimism of Hobbes and the dreams of Thomas More were equally repugnant to him. One-half, at least, of the "Theologico-Political Treatise" which appeared in 1670, might be reprinted to-day without losing any of its appropriateness. Listen to its admirable title: "Tractatus Theologico-Politicus, continens dissertationes aliquot, quibus ostenditur, libertatem philosophandi non tantum salva pietate et reipublicæ pace posse concedi, sed eamdem nisi cum pace reipublicæ ipsaque pietate tolli non posse." For centuries past it had been supposed that society rested on metaphysical dogmas. Spinoza discerns profoundly that these dogmas, assumed to be necessary to humanity, yet cannot escape discussion; that revelation itself, if there be one, traversing, in order to reach us, the faculties of the human mind, is no less than all else amenable to criticism. I wish I could quote in its entirety that admirable Chapter XX., in which our great publicist establishes with masterly skill that dogma—new then, and still contested in our own day—which styles itself liberty of conscience.

"The final end of the state," he says, "consists not in dominating over men, restraining them by fears, subjecting them to the will of others, but, on the contrary, in permitting each one to live in all possible security; that is to say, in preserving intact the natural right of each to live without injury to himself or others. No, I say, the state has not for its end the transformation of men from reasonable beings into animals or automata; it has for end so to act that its citizens should in security develop soul and body, and make free use of their reason. Hence the true end of the state is liberty. Whosoever means to respect the rights of a sovereign should never act in opposition to his decrees; but each has the right to think what he will, and to say what he thinks, provided he content himself with speaking and teaching in the name of pure reason, and do not attempt on his private authority to introduce innovations into the state. For example: a citizen who demonstrates that a certain law is repugnant to sound reason, and holds that for that cause it ought to be abrogated—if he submit his opinions to the judgment of the sovereign, to whom alone it belongs to establish and to abolish laws, and if meanwhile he acts in no wise contrary to law—that man certainly deserves well of the state as the best of citizens. . . .

"Even if we admit the possibility of so stifling men's liberty and laying such a yoke upon them that they dare not even whisper without the approba-

tion of the sovereign, never, most surely, can they be prevented from thinking as they will. What, then, must ensue? That men will think one way and speak another; that, consequently, good faith—a virtue most necessary to the state—will become corrupted; that adulation—a detestable thing—and perfidy will be had in repute, entailing the decadence of all good and healthy morality. What can be more disastrous to a state than to exile honest citizens as evil-doers, because they do not share the opinions of the crowd and are ignorant of the art of feigning? What more fatal than to treat as enemies and doom to death men whose only crime is that of thinking independently? The scaffold, which should be the terror of the wicked, is thus turned into the glorious theatre where virtue and toleration shine out in all their lustre, and publicly cover the sovereign majesty with opprobrium. Beyond question there is only one thing to be learned from such a spectacle: to imitate those noble martyrs; or, if one fears death, to become the cowardly flatterers of power. Nothing, then, is so full of peril as to refer and submit to divine rights matters of pure speculation, and to impose laws on opinions which are, or may be, subjects of discussion among men. If the authority of the state limited itself to the repression of actions while allowing impunity to words, controversies would less often turn into seditions."

More sagacious than many so-called practical men, our speculator sees perfectly well that the only durable governments are the reasonable, and that the only reasonable governments are the constitutional. Far from absorbing the individual in the state, he gives him solid guarantees against the state's omnipotence. He is no revolutionary, but a moderate; he transforms, explains, but does not destroy. His God is not indeed one who takes pleasure in ceremonies, sacrifices, odor of incense, yet Spinoza has no design whatever to overthrow religion; he entertains a profound veneration for Christianity, a tender and a sincere respect. The supernatural, however, has no meaning in his doctrine. According to his principles, anything out of Nature would be out of being, and therefore inconceivable. Prophets, revealers, have been men like others:

"It is not thinking, but dreaming," he says, "to hold that prophets have had a human body and not a human soul, and that consequently their knowledge and their sensations have been of a different nature from ours. . . . The prophetic faculty has not been the dowry of one people only—the Jewish people. The quality of Son of God has not been the privilege of one man only. . . . To state my views openly, I tell you that it is not absolutely necessary to know Christ after the flesh; but it is otherwise when we speak of that Son of God, that is to say, that eternal Wisdom of God, which has manifested itself in all things, and more fully in the human soul, and above all in Jesus Christ. Without this wisdom no one can attain the state of beatitude, since it alone teaches us what is true and what is false, what is right and what is wrong. . . . As to what certain Churches have added, . . . I have expressly warned you that I do not know what they mean, and, to speak frankly, I may confess that they seem to me to be using the same sort of language as if they spoke of a circle assuming the nature of a square."

Was not this exactly what Schleiermacher said? And as to Spi-

noza, the fellow-founder with Richard Simon of Biblical exegesis, was not he the precursor of those liberal theologians who have in our own day shown that Christianity can retain all its glory without supernaturalism? His letters to Oldenburg on the resurrection of Jesus Christ, and of the manner in which St. Paul understood it, are masterpieces which a hundred years later would have served as the manifesto of a whole school of critical theology.

In the eyes of Spinoza it signifies little whether mysteries be understood this way or that, provided they be understood in a pious sense. Religion has one aim only, piety; and we are to appeal to it not for metaphysics, but for practical guidance. At bottom there is but one single thing in Scripture, as in all revelation: "Love your neighbor." The fruit of religion is blessedness, each one participating in it according to his capacity and his efforts. The souls that are governed by reason—the philosophic souls that have, even in this world, their life in God—are safe from death; what death takes from them is of no value; but weak or passionate souls perish almost entirely, and death, instead of being for them a simple accident, involves the foundation of their being. . . . The ignorant man who lets himself be swayed by blind passions is agitated in a thousand different directions by external causes, and never enjoys true peace of soul; for him, ceasing to suffer means ceasing to be. The soul of the wise man, on the other hand, can scarcely be troubled. Possessing by a kind of eternal necessity the consciousness of itself and of God and of things, he never ceases to be, and ever preserves the soul's true peace.

Spinoza could not endure his system to be considered irreligious or subversive. The timid Oldenburg did not conceal from him that some of his opinions seemed to certain readers to tend to the overthrow of piety. "Whatever accords with reason," replied Spinoza, "is in my belief most favorable to the practice of virtue." The pretended superiority of coarsely positive conceptions as to religion and a future life found him intractable. "Is it, I ask, to cast off religion," he was wont to say, "to acknowledge God as the Supreme Good, and thence to conclude that he must be loved with a free soul? To maintain that all our felicity and most perfect freedom consists in that love—that the reward of virtue is virtue, and that a blind and impotent soul finds its punishment in its blindness—is this a denial of all religion?" At the root of all such attacks he traced meanness of soul. According to him, any one who felt irritated by a disinterested religion involuntarily confessed reason and virtue to have no charm in his eyes, and that his pleasure would lie in living to indulge his passions if he were not restrained by fear. "Thus, then," he would add, "such a one only abstains from evil and obeys the Divine commandment regretfully as a slave, and in return for this slavery expects from God rewards which have infinitely more value in his eyes than the

Divine law. The more aversion and estrangement from good he may have felt, the more he hopes to be recompensed, and imagines that they who are not restrained by the same fear as himself do what he would do in their case—that is to say, live lawlessly." Spinoza held with reason that this manner of seeking heaven was contrary to reason, and that there is an absurdity in pretending to gain God's favor by owning to him that, did one not dread him, one would not love.

IV.

He was, however, well aware of the danger of interfering with beliefs in which few admit these subtile distinctions. *Cauté* was his motto, and, his friends having made him aware of the explosion that the "Ethica" would infallibly produce, he kept it unpublished till his death. He had no literary vanity, nor did he seek celebrity—possibly, indeed, because he was sure to obtain it without seeking. He was perfectly happy—he has told us so; let us take him at his word. He has done still better: he has bequeathed us his secret. Let all men listen to the recipe of the "Prince of Atheists" for the discovery of happiness: it is the love of God. To love God is to live in God. Life in God is the best and most perfect because it is the reasonablest, happiest, fullest—in a word, because it gives us more *being* than any other life, and satisfies most completely the fundamental desire that constitutes our essence.

Spinoza's whole practical life was regulated according to these maxims. That life was a masterpiece of good sense and judgment. It was led with the profound skill of the wise man who desires one thing only, and invariably ends by obtaining it. Never did policy so well combine means and end. Had he been less reticent, he would perhaps have met the same fate as the unfortunate Acosta. Loving truth for its own sake, he was indifferent to the abuse that his constancy in speaking it entailed, and answered never a word to the attacks made on him. For his part, he attacked no one. "It is foreign to my habits," he said, "to look out for the errors into which authors have fallen." Had he desired to be an official personage, his life would no doubt have been traversed by persecution, or at least by disgrace. He was nothing, and desired to be nothing. *Ama nesciri* was his desire, as well as that of the author of the "De Imitatione." He sacrificed everything to peace of mind, and in so doing there was no selfishness, for his mind was of importance to the world. He frequently refused wealth on its way to him, and desired only what was absolutely necessary. The King of France offered him a pension; he declined. The Elector Palatine offered him a chair at Heidelberg. "Your freedom shall be complete," he was told, "for the prince is convinced that you will not abuse it to disturb the established religion." "I do not very well understand," he replied, "within what limits it would be necessary to confine that philosophical free-

dom granted me on condition of not disturbing the established religion; and then, again, the instruction I bestowed on youth would hinder my own advance in philosophy. I have only succeeded in procuring for myself a tranquil life by the renunciation of all kinds of public teaching." He felt that his duty was to think. He thought, in fact, for humanity, whose ideas he forestalled by more than two centuries.

The same instinctive sagacity was carried by him into all the relations of life: he felt that public opinion never permits a man to be daring in two directions at once. Being a freethinker, he looked upon himself as bound to live like a saint. But I am wrong in saying this. Was not this pure and gentle life rather the direct expression of his peaceful and lovable consciousness? At that period the atheist was pictured as a villain armed with daggers. Spinoza was throughout his whole lifetime humble, meek, pious. His enemies were ingenuous enough to object to this: they would have liked him to live conformably to the conventional type, and, after the career of a demon incarnate, to die in despair. Spinoza smiled at this singular pretension, and refused to oblige his enemies by changing his way of life. He had warm friends; he showed himself courageous at need; he protested against popular indignation wherever he thought it unjust. Many disappointments failed to shake his fidelity to the republican party; the liberality of his opinions was never at the mercy of events. What, perhaps, does him more honor still, he possessed the esteem and sincere affection of the simple beings among whom he lived. Nothing is equal in value to the esteem of the lowly; their judgment is almost always that of God. To the worthy Van der Spycks he was evidently the very ideal of a perfect lodger. "No one ever gave less trouble," was their testimony given some years after his death to Colerus. "While in the house he inconvenienced nobody; he spent the best part of his time quietly in his own room. If he chanced to tire himself by too protracted meditation, he would come down-stairs and speak to the family about any subject of common talk, even about trifles." In fact, there could never have been a more affable inmate. He would often hold conversations with his hostess, especially at the time of her confinements, as well as with the rest of the household when any sorrow or sickness befell them. He would tell the children to go to divine service, and, when they returned from the sermon, ask them how much they remembered of it. He almost always strongly seconded what the preacher had said. One of the persons he most esteemed was the pastor Cordes, an excellent man and good expounder of the Scriptures; sometimes, indeed, he went to hear him, and he advised his host never to miss the preaching of so able a man. One day his hostess asked him if he thought she could be saved in the religion she professed. "Your religion is a good one," he replied; "you should not seek any other, nor doubt that yours will procure salvation if, in

attaching yourself to piety, you lead at the same time a peaceful and tranquil life."

His temperance and good management were admirable. His daily wants were provided for by a handicraft in which he became very skillful—the polishing of lenses. The Van der Spycks made over to Colerus scraps of paper on which Spinoza had noted down his expenses; these averaged about fourpence halfpenny a day. He was very careful to settle his accounts every quarter, so as neither to spend more nor less than his income. He dressed simply if not poorly, but his aspect radiated serenity. It was evident that he had found out a doctrine which gave him perfect content.

He was never elated, and never depressed; the equability of his moods seems wonderful. Perhaps, indeed, he may have felt some sadness when the daughter of his professor, Van den Ende, preferred Kerkering to him; but I suspect that he soon consoled himself. "Reason is my enjoyment," he would say, "and the aim I have in this life is joy and serenity." He objected to any praise of sadness.

> "It is superstition," he maintained, "that sets up sadness as good, and all that tends to joy as evil. God would show himself envious if he took pleasure in my impotence and in the ills I suffer. Rather in proportion to the greatness of our joy do we attain to a greater perfection and participate more fully in the divine nature. . . . Joy, therefore, can never be evil so long as it be regulated by the law of our true utility. A virtuous life is not a sad and sombre one, a life of privations and austerity. How should the Divinity take pleasure in the spectacle of my weakness, or impute to me, as meritorious, tears, sobs, terrors—signs all of an impotent soul? Yes," he added, emphatically, "it is the part of a wise man to use the things of this life, and enjoy them as much as possible; to recruit himself by a temperate and appetizing diet; to charm his senses with the perfume and the brilliant verdure of plants; to adorn his very attire; to enjoy music, games, spectacles, and every diversion that any one can bestow on himself without detriment to character. . . . We are incessantly spoken to of repentance, humility, death; but repentance is not a virtue, but the consequence of a weakness. Nor is humility one, since it springs in man from the idea of his inferiority. As to the thought of death, it is the daughter of fear, and it is in feeble souls that it sets up its home. . . . The things of all others," he would say, "about which a free man thinks least is death. Wisdom lies in the contemplation not of death, but of life."

V.

Since the days of Epictetus and Marcus Aurelius, no life had been witnessed so profoundly penetrated by the sentiment of the Divine. In the twelfth, thirteenth, sixteenth century, rationalistic philosophy had numbered very great men in its ranks, but it had had no saints. Occasionally a very repulsive and hard element had entered into the finest characters among Italian freethinkers. Religion had been utterly absent from those lives not less in revolt against human than divine laws, of which the last example was that of poor Vanini. Here, on the contrary, we have religion producing free thought as a part of

piety. Religion in a system such as this is not a portion of life: it is life itself. That which is seen to matter here is not the being in possession of some metaphysical phrases more or less correct: it is the giving to one's life a sure pole, a supreme direction—the ideal.

It is by so doing that your illustrious countryman has lifted up a banner which still avails to shelter beneath it all who think and feel nobly. Yes, religion is eternal; it answers to the first need of primitive as well as of civilized man; it will only perish with humanity itself—or, rather, its disappearance would be the proof that degenerate humanity was about to reënter the mere animalism out of which it had emerged. And yet no dogma, no worship, no formula, can in these days of ours exhaust the religious sentiment. We must confront with each other these seemingly contradictory assertions. Woe to him who pretends that the era of religions is past! Woe to him who imagines it possible to restore to the old symbols the force they had when they leaned upon the imperturbable dogmatism of other days! With that dogmatism we, for our part, must needs dispense; we must dispense with those fixed creeds, sources of so many struggles and divisions, but sources no less of such fervent convictions; we must give up believing that it is our part to hold down others in a faith we no longer share. Spinoza was right in his horror of hypocrisy: hypocrisy is cowardly and dishonest, but, above all, hypocrisy is useless. Who is it, indeed, that is deceived here? The persistency of the higher classes in unqualifiedly patronizing, in sight of the uncultivated classes, the religious reforms of other days, will have but one effect: that of impairing their own authority at those times of crisis when it is important that the people should still believe in the reason and the virtue of a few.

Honor, then, to Spinoza, who has dared to say: "Reason before all." Reason can never be contrary to the well-understood interests of humanity. But we would remind those who are carried away by unreflecting impatience, that Spinoza never conceived of religious revolution as being aught else than a transformation of formulas. According to him, what was fundamental went on subsisting under other terms. If he, on one hand, energetically repudiated the theocratic power of the clergy, as distinguished from civil society, or the tendency of the state to occupy itself with metaphysics, on the other hand, he never denied either the state or religion: he wished the state tolerant and religion free. We wish for nothing more. One cannot impose on others beliefs one does not possess. That the believers of other days made themselves persecutors, proved them tyrannical, but at least consistent; as for us, if we were to act as they did, we should be simply absurd. Our religion is a sentiment capable of clothing itself in numerous forms. These forms are free from being equally good; but not one of them has strength or authority to expel all others. Freedom—this is the last word of Spinoza's religious policy.

Let it be the last word of ours! It is the most honest course; it may, perhaps, also be the most efficacious and certain for the progress of civilization.

Humanity, indeed, advances on the way of progress by prodigiously unequal steps. The rude and violent Esau is out of patience with the slow pace of Jacob's flock. Let us give time to all. We may not, indeed, permit simplicity and ignorance to hinder the free movements of the intellect, but let us not either interfere with the slow evolution of less active intelligences. The liberty of absurdity in these is the condition of the liberty of reason in those. Services rendered to the human mind by violence are not services after all. That such as lay no stress on truth should exercise constraint in order to obtain outward submission, what can be more natural? But we, who believe that truth is something real, and deserving of supreme respect, how can we dream of obtaining by force an adherence which is valueless except as the fruit of free conviction? We no longer admit sacramental formulas operating by their own virtue independently of the mind of him to whom they are applied. In our eyes, a belief has no worth if it be not gained by the reflection of the individual—if he have not understood and assimilated it. A mental conviction brought about by superior order is as absolute nonsense as love obtained by force or sympathy by command. Let us promise to ourselves not only to defend our own liberty against all who seek to attack it, but, if need be, to defend the liberty of those who have not always respected ours, and who, it is probable, if they were the masters, would not respect it.

It is Holland that had the glory, more than two hundred years ago, to demonstrate the possibility of these theories by realizing them.

> "Must we prove," said Spinoza, "that this freedom of thought gives rise to no serious inconvenience, and that it is competent to keep men, openly diverse in their opinions, reciprocally respectful of each other's rights? Examples abound, nor need we go far to seek them. Let us instance the town of Amsterdam, whose considerable growth—an object of admiration to other nations—is simply the fruit of this freedom. In the midst of this flourishing republic, this eminent city, men of all nations and all sects live together in most perfect concord; . . . and there is no sect, however odious, whose adepts, provided they do not offend against the rights of any, may not meet with public aid and protection before the magistrates."

Descartes was of the same opinion when he came to ask from this country the calm essential to his thinking. Later—thanks to that noble privilege of a free land so gloriously maintained by your fathers against all opponents!—your Holland became the asylum where the human intellect, sheltered from the tyrannies that overspread Europe, found air to breathe, a public to comprehend it, organs to multiply its voice, then gagged elsewhere.

Deep, assuredly, are the wounds of our age, and cruel are its perplexities. It can never be with impunity that so many problems present themselves all at once before the elements for solving them are in our possession. It is not we who have shattered that paradise of crystal, with its silver and azure gleams, by which so many eyes have been ravished and consoled. But there it is in fragments; what is shattered is shattered, and never will an earnest spirit undertake the puerile task of bringing back ignorance destroyed or restoring illusions dispelled. The populations of great towns have almost everywhere lost faith in the supernatural; were we to sacrifice our convictions and our sincerity in an attempt to give it them back, we should not succeed. But the supernatural, as formerly understood, is not the ideal.

The cause of the supernatural is compromised, the cause of the ideal is untouched; it ever will be. The ideal remains the soul of the world, the permanent God, the primordial, efficient, and Final Cause of this universe. This is the basis of eternal religion. We, no more than Spinoza, need, in order to adore God, miracles or self-interested prayers. So long as there be in the human heart one fibre to vibrate at the sound of what is true, just, and honest; so long as the instinctively pure prefer purity to life; so long as there be found friends of truth ready to sacrifice their repose to science; friends of goodness to devote themselves to useful and holy works of mercy; woman-hearts to love whatever is worthy, beautiful, and pure; artists to render it by sound, and color, and inspired accents—so long will God live in us. It could only be when egoism, meanness of soul, narrowness of mind, indifference to knowledge, contempt for human rights, oblivion of what is great and noble, invaded the world—it could only be then that God would cease to be in humanity. But far from us thoughts like these!

Our aspirations, our sufferings, our very faults and rashness, are the proof that the ideal lives in us. Yes, human life is still something divine! Our apparent negations are often merely the scruples of timid minds that fear to overpass the limits of their knowledge. They are a worthier homage to the Divinity than the hypocritical adoration of a spirit of routine. God is still in us; believe it. God is in us! *Est Deus in vobis.*

Let us all unite in bending before the great and illustrious thinker who, two hundred years ago, proved better than any other, both by the examples of his life and by the power, still fresh and young, of his works, how much there is of spiritual joy and holy unction in thoughts like these. Let us, with Schleiermacher, pay the homage of the best we can do to the ashes of the holy and misunderstood Spinoza:

"The sublime spirit of the world penetrated him; the infinite was his beginning and his end; the universal his only and eternal love. Living in holy innocence and profound humility, he contemplated himself in the eternal world, and

saw that he, too, was for that world a mirror worthy of love. He was full of religion and full of the holy spirit; and therefore he appears to us solitary and unequaled, master in his art, but lifted above the profane, without disciples, and without right of citizenship anywhere."

That right of citizenship you are now about to confer on him. Your monument will be the link between his genius and the earth. His spirit will brood like a guardian angel over the spot where his rapid journey among men came to its end. Woe to him who, in passing by, should dare to level an insult at that gentle and pensive figure! He would be punished as all vulgar hearts are punished—by his very vulgarity and his impotence to comprehend the divine. Spinoza, meanwhile, from his granite pedestal shall teach to all the way of happiness he himself had found; and for ages to come the cultivated man who passes along the Pavilioengragt will inwardly say, "It is hence, perhaps, that God has been seen most near!"—*Contemporary Review.*

TRANSMISSION OF EXCITATIONS IN SENSORY NERVES.[1]

BY PAUL BERT.

PHYSIOLOGISTS are as yet by no means agreed whether the nerves which, from their special functions, have been termed *motor* and *sensor* nerves, are in their essential properties identical or different; in other words, whether a sensor nerve can transmit excitations whose result is motion, and *vice versa.* We do not even know whether an excitation produced midway in the length of a nerve is simultaneously propagated in both directions, centrifugally and centripetally. The admirable experiments made by Philipeaux and Vulpian to determine these knotty questions are, as Vulpian was the first to observe, susceptible of a different interpretation from that unanimously put upon them by the world of science.

Such being the state of the case, I thought it advisable to take up again an experiment I had made in 1863,[2] but which I had neglected to prosecute, in view of the apparently far more conclusive and far more general results obtained by the able experimenters just named. This experiment I have now completed, and strengthened against any objection that might have been raised against it.

If we pinch a sensor nerve at any point of its length, the pain that is felt clearly shows that the excitation is propagated in the centripetal direction; but of a centrifugal propagation we know nothing, for the very simple reason that at the terminal extremity of the nerve

[1] Translated from the French by J. Fitzgerald, A. M.

[2] *Comptes rendus de la Société de Biologie* (1863), p. 179.

there is no nervous apparatus of perception. But if we can bring this extremity into relation with the perceptive centre, the brain, we shall see whether there is sensation, which would imply centrifugal propagation.

The means employed in bringing about this condition of things is very simple indeed. I remove, for the length of two or three centimetres, the skin from the tip of a young rat's tail, and insert the flayed part into the subcutaneous cellular tissue through an opening made in the skin of the animal's back. A few stitches suffice to hold the parts in place, and soon they adhere firmly, the rat's tail then having the *ansate* form.

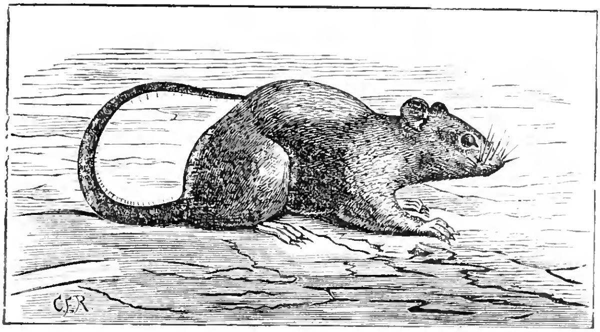


FIG. 1.—RAT WITH TIP OF TAIL INSERTED INTO THE DORSAL TISSUES.

Eight months later I cut the tail in two, thus leaving two caudal stubs. Immediately after section, the dorsal stub was manifestly sensitive; and when it was pinched vigorously, the rat would squeal and run off. Hence it plainly appears that, in this fragment of a tail, the excitation of the sensor nerves is propagated from the thick to the slender end, or in a direction inverse to what is held to be the normal course. The process was about as follows: the sensor nerves distributed to the extremity of the tail, on being wounded by the removal of the skin, united with the sensor nerves of the dorsal region, which in like manner had been cut into. In due course of time the nerve-cicatrix became able to transmit the shocks (whatever their nature) which an excitation produces in a nerve. When, now, we pinch the extremity of the dorsal stub, the shock is transmitted along the excited caudal nerve, passes through the cicatrix, and follows the dorso-cutaneous nerve into the spinal marrow, which carries it to the brain, where it results in a sensation of pain.

The history of the case will be readily understood on examining the following diagram, in which, for simplicity's sake, I have represented only one of the nerve-filaments of the tail (*N C*) and one of the nerve-filaments of the back (*D N*).

But this sensibility of the dorsal fragment begins to grow less on

the second day after section, and soon it is gone. If, some days later, we examine the nerves of this fragment with a microscope, we shall find that they have undergone the changes usual in nerves that have been cut off from their trophic centres; and this is true no less of the portion concealed under the skin than of the free (and certainly living) portion hanging from the animal's back: not a single sound nerve-

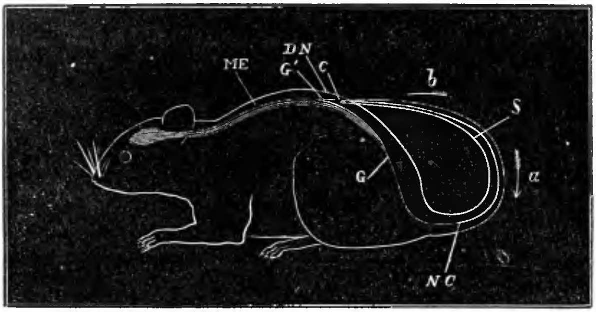


Fig. 2.—*M E*, spinal marrow. *N C*, nerve-filament distributed to the end of the tail. *G*, its trophic ganglion. *D N*, a nerve-filament distributed to the skin of the back, lacerated in the operation. *G*, its trophic ganglion. *C*, the cicatrix which united the two nerves, and which is now permeable to nervous shocks. *S*, point where the tail was cut in two; *a*, *b*, arrows showing the two directions in which sensory excitations are transmitted.

tube is to be seen in it. On the contrary, the stump of the tail, which has retained its natural position, has every nerve sound, with not a single diseased tube.

Thus, then, physiological facts are in agreement with histological observations, and they both prove conclusively that the sensor nerves which transmitted the centrifugal excitation were the normal nerves of the dorsal stub, and that here we have neither new-formed nerves nor nerve-fibres with ansate terminations. It is further demonstrated —and this is a fact not without interest—that the relations with the nerve-centres of perception, from which results sensation, are more easily established than those with the trophic ganglionic centres, which nourish the sensor nerves. Who knows but that, had I waited longer before I cut the tail in two, the influence of the new trophic centres would have become sufficient to maintain the nerves of the dorsal fragment in their integrity, and that sensibility would have persisted after section? Some months after the dorsal stub had become insensible, it again regained sensibility, the diseased nerves having been regenerated. At first, just as I had observed in 1863, the animal refers the impression it receives to the region of the back where the nerve-cicatrix is: this is the reverse of the illusion observed in cases of amputation. By little and little the rat is educated, and at last recognizes the exact point that is excited; thus showing that our so-called innate knowledge of the place occupied in space by every point of our bodies is, like all our knowledge, merely the result of repeated experiences.

To conclude, the experiment I have just recounted shows that excitation of a sensor nerve at any point of its length is propagated in two directions, both centrifugally and centripetally. The same is doubtless true of a motor nerve. Consequently, it is highly probable that, as Vulpian has held, the nerves are simple conductors, differentiated only by their functions, which latter depend upon the kind of apparatus at their two extremities: for motor nerves there is a motor nerve-cell and muscular fibre, and for sensor nerves a receiving nerve-cell and an impressionable termination.—*La Nature.*

ON THE PHYSICAL CONDITION OF JUPITER AND SATURN.

BY DAVID TROWBRIDGE, ESQ.

NOT many years ago the planets Jupiter and Saturn were regarded as solid bodies, their small relative density being supposed to be due either to the peculiar arrangement of the materials which compose them, or to the small specific gravity of the materials themselves. Within a few years, however, the nebular hypothesis has gained so strong a hold on the minds of astronomers, that the larger planets are regarded in a very different light as respects their physical condition from what they were a few years ago. It is now thought that at least Jupiter and Saturn, and probably Uranus and Neptune, have not yet cooled down from their heated and nebulous condition sufficiently to be habitable globes, and that, owing to their relatively high temperature, they have very extensive atmospheres.

It is quite possible for us to guess at the extent and density of their atmospheres, but, unless we subject our guesses to calculation, it cannot be said that they are of much use to us, since the planets are too far from us to allow direct observations to settle any points in dispute. Let us, therefore, assume Jupiter and Saturn to be globes of much higher temperature than the earth's, and that this temperature varies from the surface upward inversely as the square of the distance from the centre of the planet. Let us further assume that gases there follow the same law of expansion as terrestrial gases, and that this law holds for all temperatures above 32° Fahr. With these assumptions, it is possible for us to subject our *guesses* to calculation, and thus learn how far they are admissible.

As respects the telescopic appearance of those planets, it is plain that we have but little evidence of an atmosphere outside the highest cloud-layers. That their atmospheres extend above the highest clouds is perhaps certain; but if we attempt to explain the physical appear-

ance of those planets, the condition of the atmosphere above the clouds may be left out of the consideration. Let us assume the density of the atmosphere at the upper surface of the clouds to be equal to that of our atmosphere at the height of about fifteen miles, and we shall perhaps regard it as sufficiently rare. The height of the upper cloud-layers above the surface proper of the planets will now depend on the surface-temperature and on the mass of the atmosphere. The *law* of density for different heights above the surface of the planets is almost independent of the mass of the atmosphere, unless we consider the mass as very great in comparison with that of the planet which it surrounds.

Let us suppose the density of the atmosphere at the surface of the planet to be equal to that of water—and such a density is certainly too great for either Jupiter or Saturn—it is then possible for us to calculate the height of the cloud-layers to which we have already referred, if the temperature be given; or, if the height be given, to calculate the temperature of the surface of the planet. We have seen it suggested that, if this height be assumed equal to 2,000 miles, it will enable us to explain the telescopic appearances of Jupiter and Saturn. This height for the former planet requires a surface-temperature of 45,000°, and for the latter 20,000° Fahr. It seems to be quite evident that these temperatures are much too high. That Jupiter and Saturn give out more light than they receive from the sun, seems nearly certain; but a temperature of 20,000° would seem to imply a much greater intrinsic splendor than either Jupiter or Saturn possesses.[1]

Prof. Proctor, in one of his articles, assumes the height of the highest cloud-layers to be 100 miles above the surface of the planet. This implies a temperature of 1,800° for the surface of Jupiter, and of 600° for that of Saturn. We must now conclude that the cloud-layers which form the outlines of the disks of Jupiter and Saturn are scarcely 100 miles high on Saturn, and considerably less on Jupiter; for we have assumed the surface-density much too high, and probably the density of the upper cloud-layers much too small. We cannot certainly consider the temperature of either planet above 2,000° Fahr.

The Herschelian figure of Saturn can probably be explained by the surface cloud-layers in its atmosphere. We need a greater number of and more careful observations on Jupiter and Saturn.

[1] These calculations are based on a mathematical paper read before the American Philosophical Society, November 3, 1876.

SKETCH OF ALFRED RUSSEL WALLACE.

ALFRED RUSSEL WALLACE, an English naturalist, was born at Usk, Monmouthshire, January 8, 1822. He was employed for several years in the architectural office of his brother, and then devoted himself to natural history. In 1848 he accompanied Mr. H. W. Bates in a scientific expedition to Brazil, where, after a protracted sojourn in Pará, he explored the primeval forests of the Amazon and Rio Negro, returning to England in 1852. His valuable collections, especially rich in the departments of ornithology and botany, were in great part destroyed by shipwreck. In 1853 he published "Travels on the Amazon and Rio Negro" and "Palm-Trees of the Amazon and their Uses," and in 1854 undertook a journey to the East Indies, where for a period of nearly eight years he explored the greater part of the islands constituting the Malay Archipelago, and portions of Papua. While pursuing his researches relative to the fauna and flora of these regions, Mr. Wallace, unaware of Darwin's previous labors in the same direction, attempted the solution of the problem of the origin of species, and arrived at almost the same general conclusions which were simultaneously reached by that naturalist. His paper "On the Tendency of Varieties to depart indefinitely from the Original Type," transmitted through Sir Charles Lyell to the Linnæan Society, was read before that body on July 1, 1858, coincidently with the reading of Mr. Darwin's paper "On the Tendency of Species to form Varieties, and on the Perpetuation of Species and Varieties by means of Natural Selection." Though recognizing the efficacy of natural selection in producing most of the changes attributed to its action by Mr. Darwin, he denies its competence to effect, without the joint agency of some higher cause, the transition to man from the anthropoid apes. In 1862 Mr. Wallace returned to England, where for several years he was mainly engaged in the classification of his vast collection, which embraced upward of 100,000 entomological specimens, and more than 8,000 birds. The results of his Eastern explorations were partially embodied in "The Malay Archipelago: the Land of the Orang-utan and the Bird-of-Paradise" (1869). Mr. Wallace has of late been prominently associated with the believers in the so-called spiritualistic phenomena, to the examination of which he has devoted special attention. His observations were published in a series of essays in the *Fortnightly Review* for 1874, reprinted as "Miracles and Modern Spiritualism" (1875). In 1868 he received the royal medal from the Royal Society, and in 1870 the gold medal from the Geographical Society of Paris. In 1870 he published "Contributions to the Theory of Natural Selection." His elaborate work "On the Geographical Distribution of Animals" (2 vols.) appeared in 1876 in English, French, and German.

CORRESPONDENCE.

A CURIOUS SALINE DEPOSIT.

To the Editor of the Popular Science Monthly.

SIR: A singular natural phenomenon has recently come under my observation. As I have never heard of it before, and as it appears almost incredible to all who have heard me speak of it, I thought it well to give it publicity through the columns of your monthly.

During the present month, while out on a scouting expedition, I spent three days in Deep Spring Valley, a lonely place in the White Mountains in Inyo County, California. During one day of my stay, the 5th of March, I found that the Indians were catching wild aquatic birds of all sorts in Deep Spring Lake by simply wading into the water and seizing them with the hands. The birds, at that time, had their plumage so heavily coated with a saline compound that they were totally unable to fly, and thus fell an easy prey to the savages. On inquiry, I was told that this salt formed on the birds' breasts and wings, so as to prevent flight, only during a very short season of the year, and then under a peculiar combination of circumstances. The season lasts from about the first of March to the middle of April, and the birds can only be caught from dawn until about nine o'clock in the day, when the previous night has been perfectly clear, with a gentle wind from the north. The birds are then found in the southern part of the lake, incrusted with the salt. On the first night that I spent there the sky was cloudy and the wind was from the north; on the third night the sky was clear and the wind was from the south, and no ducks were caught on the following morning; and from my own observation I can say that none were incrusted. But during the second night of my stay the conditions were exactly favorable, and ducks were caught in abundance next day. In 1875 I visited the same locality in the month of December, and neither heard nor saw anything of this mode of catching water-fowl.

I weighed one duck immediately after it was caught, with all the incrustation intact, and again when the salts were cleaned off, and found that the latter weighed six pounds. The duck seemed to have been drowned by its burden; its eyes and bill were completely closed by a large lump of the salt.

Some small fresh streams enter the lake at the northern end; and on the favorable nights the Indians take the precaution to build fires and hang out cloths at the mouths of these streams, to prevent any of the ducks from entering the fresher water and thus having the salty incrustation dissolved or washed off. During these favorable nights, also, the Indians collect on the southeastern shore of the lake and perform a duck-dance, in which they artistically imitate the motions, habits, and calls, of different kinds of water-fowl. Throughout my entire sojourn on the shores of the lake, its shallow waters were rendered turbid by the wind; but they were equally turbid with a south as with a north wind.

As the lake of which I speak is the only one known to these Indians where ducks may be caught in this manner, it may be well to describe it more particularly. It lies in a desert valley, 6,200 feet above the sea. It is about one mile in length from north to south, and about three-quarters of a mile wide from east to west. Its average depth does not exceed three feet, although there are a few deeper holes in it. The land around is sandy, and covered with "sage-brush." During the past summer the Indians took from the bottom of the lake several tons of salt, which was sold to quartz-mills in this neighborhood as chloride of sodium, sufficiently pure to be used in the reduction of ores. It is said that the amount obtained in two days was fourteen tons; but this estimate may be taken, in more senses than one, *cum grano salis.*

I send you a specimen of the salt, which I gathered myself from one of the ducks, and am very anxious that you would have it analyzed. W. W. WOTHERSPOON,
Lieutenant Twelfth U. S. Infantry.

CAMP INDEPENDENCE, INYO CO., CAL., *March* 15, 1877.

The following analysis, made by Dr. Elwyn Waller, of the School of Mines, Columbia College, gives the composition of the deposit above referred to:

*Sulphate of soda	57.37	per cent.
*Sulphate of potash	8.09	"
Chloride of potassium	0.82	"
Carbonate of lime	2.24	"
Carbonate of magnesia	2.50	"
Sand and clay	10.41	"
Moisture	16.30	"
Bicarbonate of soda	(trace)	"
Organic matter	2.32	"
	100.05	

FERMENTATION AND DISEASE.

To the Editor of the Popular Science Monthly.

PROF. TYNDALL'S lecture on "The Relation of Fermentation to Putrefaction and

* Calculated from the data afforded by the weight of the combined sulphates, and a determination of the sulphuric acid present.

Disease" explains so many phenomena which I have noticed, that I am disposed to accept it with avidity. Nevertheless, there seem to be some contradicting facts. Once, when serving with a troop of cavalry, a young and apparently healthy beef was brought to us, which we slaughtered, and set about cooking immediately. To our surprise, the flesh was tainted. To the senses of taste and smell the taint could not be distinguished from incipient putrescence. A careful examination failed to detect any signs of disease in the entrails or any part of the animal. The time which elapsed from the killing of the beef until the flesh was tasted was only a few minutes, certainly not half an hour. It was in Louisiana, in the month of April, late in the evening, and in cool weather; notwithstanding unprejudiced stomachs and resolute appetites, we were obliged to desist, and make a hungry camp.

Another instance, and much more incompatible with the bacterial theory of putrefaction as set forth by Prof. Tyndall, I find in Dr. Kane's narrative of his Arctic expedition. I have not the work at hand to refer to the page, but it is where, in the early dawn of the arctic morning, he watched several times for a reindeer which had been indistinctly seen, in the faint light, haunting a valley about a mile or two from the ice-bound ship. He finally succeeded in killing it, and his men ate one meal; but the carcass putrefied before they could eat again. This, and the temperature of the air many degrees below zero! He goes on to say that the sudden putrefaction of meat in the arctics is common; that sometimes a bear or a deer would spoil before it could be flayed. Can it be that there are arctic bacteria?—that in warmer countries there are exceptional kinds which hasten putrefaction at such a rate? Can it be that the cells of the flesh in certain circumstances produce putrefaction, somewhat as the cells of fruit produce fermentation? Or, finally, is it so that, both in the case of Dr. Kane's reindeer and in that of my beef, the animal had eaten something which gave the flesh a bad flavor, and our imagination supplied much more than we supposed? The facts need some explanation, and, in the case of Dr. Kane, are of such weight as should challenge the general attention of observers.

M. M. Kenney.

Brenham, Texas, *March* 25, 1877.

THE ORIGIN OF HONEY-DEW.

To the Editor of the Popular Science Monthly.

Dear Sir: Mr. Darwin says, in his last work, "Cross and Self Fertilization in the Vegetable Kingdom," page 402: "Many years ago I suggested that, primarily, the saccharine matter in nectar was excreted as a waste product of chemical changes in the sap; and that, when the excretion happened to occur within the envelopes of a flower, it was utilized for the important object of cross-fertilization, being subsequently much increased in quantity and stored in various ways. This view is rendered probable by the leaves of some trees excreting, under certain climatic conditions, without the aid of special glands, a saccharine fluid, often called honey-dew." In the mountains of North Carolina there is a species of honey-dew eagerly sought for by bees, which is rarely seen by persons who have written of it, and is by many supposed to be a myth; but Mr. Rufus Morgan, one of the best informed and most successful apiarians of that section, who has for several years examined it in all its stages, is convinced that it is an animal, not a vegetable exudation. In reply to my questions respecting it, he writes:

"The phenomenon is not only well known in my section of the State, but is of annual recurrence. I have frequently studied it on green leaves, generally in the month of June or July, and invariably found it in close vicinity to the well-known aphides, or plant-lice, always below them, whence I concluded they wounded the leaves and caused this sap or 'honey' to flow. But, on further examination, I was fortunate enough to witness an actual shower of dew, in almost infinitesimal globules; and, on getting the sunlight at the right angle, these particles could be traced to these little creatures.

"It was a perfectly quiet day, and they seemed to eject the globules with some force, making them fly clear of the leaf and fall on the leaves below. Of course, such small particles would be wafted away by even a gentle wind, and, not being accompanied by their cause, their origin would necessarily be obscure.

"Last spring, before any leaves were out, I witnessed a most extraordinary yield of it on the pines. It hung in great drops, and fell off like real dew when the branches were shaken. At first I was mystified as to its origin, as I could find no aphides, which, according to my theory, ought to be present; but on a closer inspection I found them in abundance, not on the green, but on the dark or woody part of the twig. As these little insects are of the same color as the substance on which they are found, they are noticed only by close observers; but there is no doubt in my mind that the honey-dew is an exudation from them. These insects are also called 'ant-cows,' from the fact of ants seeming to suck them, when they are only gathering this sweet secretion. It will be hard to convince the public of this simple origin of the honey-dew, as, of the hundreds with whom I conversed respecting it last year, none would accept my views,

except the few whom I took to the trees and showed the philosophy of it, and even they seemed to regret that I had spoiled a pet delusion."

In his "Origin of Species," page 97, Mr. Darwin, in speaking of the inability of the hive-bee to suck nectar from the red-clover flowers, says: "I have been assured that when red clover has been mown, the flowers of the second crop are somewhat smaller, and that these are visited by many hive-bees. I do not know whether this statement is accurate, nor whether another published statement can be trusted, namely, that the Ligurian bee, which is generally considered a mere variety, and which freely crosses with the common hive-bee, is able to reach and suck the nectar of the common red clover."

Both of these statements Mr. Morgan confirms, and, acting on the fact that the Ligurian or Italian bee can procure honey not only from the red clover but other flowers of his section, in which the nectar is inaccessible to the common or black bee, he has Italianized his whole apiary by crossing the black and Ligurian bees, and finds the cross stronger and better honey-gatherers than the common bee. These facts, as coming from a practical apiarian, may be interesting to the readers of The Popular Science Monthly, and therefore I have ventured to send them to you. M. B. C.

New Berne, North Carolina.

EDITOR'S TABLE.

THE POPULAR SCIENCE SUPPLEMENTS.

TWO great tendencies of modern thought are every year more and more marked: one relating to its character, and the other to the form of its expression. The thinking of the age is taking a scientific direction, and becoming more profoundly imbued with the scientific spirit, while the leading minds of all nations are contributing their choicest work for periodical publication. Not only are old sciences perfecting and new ones arising with a rapid development of positive knowledge, but the method of the movement is steadily extending to all spheres of opinion, and influencing important questions with which it was long supposed that science had nothing to do. It is one of the marked effects of the recent growth and diffusion of the scientific spirit that it is giving a new earnestness and seriousness to literary effort, bringing forward questions of universal interest into greater prominence, and inducing in the most eminent minds a desire to communicate more directly and immediately with the people, by the readiest modes of publication. Hence, in England, France, and Germany, as well as in this country, the best thought appears in the popular magazines. A further result of this tendency to earnestness, in recent periodical writing, is that authors are taking the responsibility of their work before the public, by attaching their names to their magazine contributions. The old and vicious system of anonymous writing in the reviews is declining, and giving place to the open, manly, and honest expression of the writer's convictions. Through the operation of such causes, periodical literature is acquiring a weight and influence in our time much greater than it has ever had before.

The Popular Science Monthly was established in recognition of these tendencies, and to make the vigorous, valuable, and independent intellectual work of the age, wherever done, more accessible to American readers. We have drawn, for our articles, from foreign sources, because science is of no nationality, and it is an obvious dictate of common-sense to get the best things wherever they are to be had. This policy has been approved by the public, and now, after ten volumes have appeared, we find our limits so inadequate that an increase of facilities becomes necessary to secure the object for which the magazine was started.

So many excellent things have been constantly slipping by us for which there was no room in the pages of THE MONTHLY — so many sterling papers which our readers would prize, and have often called for—that we find ourselves now compelled to resort to the issue of supplements in order to accomplish the purpose at first had in view. The volumes that we have thus far furnished undoubtedly contain the largest amount of varied and valuable mental work to be found within equal limits in any periodical of any country, and we now intend to increase its scope and influence by the help of these supplementary issues, so as to meet the augmenting requirements of the times, and make this publication the completest reflection of the scientific and philosophic progress of the age that can be anywhere obtained. It will represent the course of contemporary thought on subjects of leading interest, preserve its most permanent elements, and form a comprehensive and independent scientific library, well suited to the wants of non-scientific people.

During the ensuing year THE POPULAR SCIENCE SUPPLEMENTS will appear once a month, containing, each, ninety-six pages, price twenty-five cents; and they will contain the freshest and most important articles that appear abroad, of the same general character as the past contents of THE POPULAR SCIENCE MONTHLY. Objection has sometimes been made that THE MONTHLY is high-priced, but it has been furnished as cheaply as the nature of the enterprise would allow. There is no maxim of trade more sound and practical than that value must be paid for, and that the lowest-priced goods are always the poorest, and but rarely the cheapest. Quality should certainly be taken into account in our mental nutriment if anywhere, and THE POPULAR SCIENCE MONTHLY and its SUPPLEMENTS will furnish the cheapest first-class reading in the United States.

JEVONS ON "CRAM."

PROF. JEVONS has contributed an article to *Mind* (copied into THE POPULAR SCIENCE SUPPLEMENT, No. 1), in which he attempts a defense of "cram" in connection with the system of competitive examinations. Such is the working of that system, and so inevitably does it lead to cramming, that it is not difficult to see either that the system must be abandoned or "cram" defended; and Prof. Jevons intrepidly takes the latter alternative. We admire his pluck but condemn his logic. Clear thinker as he is, in this brilliant and specious paper he has simply confused an important subject in the interest of a questionable cause.

He makes his case by drawing a distinction between two sorts of "cram," which he calls "good cram" and "bad cram." He says: "A candidate, preparing for an important competitive examination, may put himself under a tutor well skilled in preparing for that examination. The tutor looks for success by carefully directing the candidate's studies into the most 'paying' lines, and restricting them rigorously to those lines. The training given may be of an arduous, thorough character, so that the faculties of the pupil are stretched and exercised to their utmost in those lines. This would be called 'cram,' because it involves exclusive devotion to the answering of certain examination-papers. I call it 'good cram.'

"'Bad cram,' on the other hand, consists in temporarily impressing upon the candidate's mind a collection of facts, dates, or formula, held in a wholly undigested state, and ready to be disgorged in the examination-room by an act of mere memory. A candidate unable to appreciate the bearing of Euclid's reasoning in the first book of his 'Elements,' may learn the propositions off by heart—diagrams, letters, and all—like a Sunday-scholar learning

the collects and gospels. Dates, rules of grammar, and the like, may be 'crammed' by mnemonic lines," etc.

We object to this distinction. "Bad cram" means a great deal more than Prof. Jevons here indicates; and his "good cram" is either "bad cram" or no "cram" at all. He is mistaken in limiting what he calls "bad cram" to loading the memory with formula without understanding principles, as in the illustration he offers of Euclid's "Elements." It is possible to "cram" the apprehension of a subject as well as its verbal forms. We knew a young lady in one of our leading academies, the only female student in a geometry-class of twenty, who, under the spur of feminine vanity, kept her position at the head of the class for the whole term, giving the demonstrations every time when the gentlemen broke down, and having the clearest understanding of the subject which such a prolonged ordeal compelled, while the whole experience amounted to nothing for permanent effect. The boasted discipline was a pure illusion. She lived for a whole term in a sort of atmosphere of geometrical excitement, and upon leaving the school the mathematical fever subsided and the geometry disappeared like a dream. It was a case of pure "cram." Time was not taken for digestion—for the deepening of acquisition and the consolidation of mental habits. "Cram" refers not so much to any form or kind of acquisition (although some favor it more than others), but rather to the rate of any acquisition. Its essential element is excessive and unnatural forcing—a stuffing of mental aliment, that may be excellent in itself, but out of relation to natural appetite or healthy assimilation. Prof. Jevons says that the epithet "cram" affords an admirable "cry" for the opponents of the examination-system; that "it is short, emphatic, and happily derived from a disagreeable physical metaphor;" by which he probably means that its metaphorical use in education is derived from a disagreeable physiological experience. But is its mental application really so metaphorical, after all? One may eat so as to keep pace with the digestive and assimilative processes of the system, or he may exceed that rate in taking food, which is cramming. But is not mental acquirement also based on physiological activity, and subject to a time-rate depending upon cerebral assimilation? The "cram" of the dining-room and the "cram" of the school-room are, at bottom, the same thing, merely involving different physiological organs.

Prof. Jevons, indeed, yields this point explicitly. He concedes the physiological basis of mental culture, in saying: "It is the very purpose of a *liberal education*, as it is correctly called, to develop and train the plastic fibres of the youthful brain so as to prevent them taking too early a definite 'set,' which will afterward narrow and restrict the range of acquisition and judgment." But if it is plastic fibres and cells that we have at last to deal with, what escape is there from the conclusion that true education — the leading out of the faculties—must take its rate from the measured processes of nervous growth?

Prof. Jevons's "good cram" is defined as arduous and thorough study directed to the winning of honors at a competitive examination. But thorough study, carried on under the conditions favorable to enduring acquisition, is not "cram" of any sort, because the term in its essential meaning excludes thoroughness. We shall not deny that much vigorous, persistent intellectual work may be accomplished under competitive inspiration, in which no "cram" is involved; and we think Prof. Jevons commits a harmful error in applying the term "cram" to such study, and undertaking to qualify it by an adjective that simply neutralizes it. Under such an authoritative sanction, all

"cram" will become "good cram," and a plausible excuse be thrown over one of the most extensive vices of education.

Prof. Jevons's object is to defend competitive examinations; and there is a painful significance in the fact that he admits the system to be so involved and bound up with the practice of "cram," that nothing remains but to wrest the word from its established meaning, and give it a new and respectable meaning. His tactics are ingenious, but nothing is gained by them. However the words are altered, the facts will remain.

Prof. Jevons strives to strengthen his view by carrying it out into the application of practical life, which he maintains to be little else than a sphere of incessant "cram." He says: "The actual facts which a man deals with in life are infinite in number, and cannot be remembered in a finite brain. . . . . In some cases we require to remember a thing only a few moments or a few minutes; in other cases a few hours or days; in yet other cases a few weeks or months; it is an infinitesimally small part of all our mental impressions which can be profitably remembered for years. Memory may be too retentive, and facility of forgetting and of driving out one train of ideas by a new train is almost as essential to a well-trained intellect as faculty of retention." He then goes on to say that the lawyer, the physician, the merchant, "deal every day with various combinations of facts which cannot all be stored up in the cerebral framework, and certainly need not be so. . . . . The practical barrister 'crams' his brief;" and "what is 'cram' but the rapid acquisition of a series of facts, the vigorous getting up of a case?"

Now the upshot of all this is, that in life we have constantly to make temporary acquisitions, and which often require vigorous exertion. But will it be pretended that the making of temporary acquisitions is the legitimate work of education? A lawyer may "cram" his case, but if he succeeds with it he must not have crammed his law. There is undoubtedly a varying value in mental acquisitions; some are not worth retaining, and others are of lasting importance. But there are facts, truths, principles, that should be indelibly engraved upon the minds of students: these should be the staple of education, and be the means of that deliberate discipline which it is the chief object of education to impart. Our educational system is virtually at fault in not having yet organized a curriculum in which acquisitions of permanent value are made fundamental. Prof. Jevons says: "If things taught at school and college are to stay in the mind, to serve us in the business of life, then almost all the higher education yet given in this kingdom has missed its mark." Exactly; and for this reason the system is under sharp arraignment, and a "new education" is demanded. Prof. Jevons's assertion that many things are not worth retaining in the mind, naturally leads to the vital question, "What knowledge is of most worth?" To make his argument good, that knowledge may be crammed because of its worthlessness, he must show that no knowledge is worth retaining, and all is to be stuffed with a view to getting rid of it.

A BASELESS RUMOR.

The Rev. Moncure D. Conway writes gossipy letters from London to the *Cincinnati Commercial*, and in his eagerness for sensational statements, as is usually the case with gossips, is quite too careless of their truth. He has started the story that the closing portions of Mr. Herbert Spencer's "Principles of Sociology" are so loosely and badly written as to indicate that Spencer is showing a decline of his mental powers. This has created anxiety in the minds of many, and we have re-

ceived various inquiries as to what ground there is for Mr. Conway's statement.

It is true that Mr. Spencer has not been in good health, and has been compelled recently to desist from labor, and it is this circumstance that just now operates to give point to Conway's opinion; but it is to be remembered that Mr. Spencer's health was not so good when he began his philosophical system in 1860 as it has been since; while in writing "First Principles" he was often compelled to stop work, and go to the country for rest and reinvigoration.

As to the evidence of mental failure to be gathered from the work on Sociology just published, we do not observe that anybody else besides Conway has found it. The volume has been widely reviewed by leading English periodicals, and none of them, that we have seen, share the discernment of the correspondent of the *Cincinnati Commercial*. On the contrary, they testify to the sustained power and originality of his work, and are more concurrent and emphatic than ever before as to Mr. Spencer's capacity to carry forward the gravest and profoundest intellectual undertaking of the age. It is, moreover, the views developed toward the close of the volume that have made the strongest impression upon the minds of the critics. They see, in his treatment of the questions there discussed, especial indications of that wide grasp and subtile analysis which have been so marked a characteristic of his previous philosophical volumes. We print elsewhere a portion of the notice of "The Principles of Sociology" that appeared in the London *Examiner*, and it will be seen that, in referring to these very views, brought out at the close of the book, the writer remarks, "It strikes us that Mr. Spencer here exhibits an increased power of seizing the many influences which contribute to a complex result." To do this in a vast field of comparatively unexplored phenomena is certainly the highest test of intellectual vigor. It is admitted by those who have reviewed the book most thoughtfully, that the ideas reached and developed by Spencer in its concluding portions are certain to exert a powerful influence in modifying the course of current opinion, and that they will give a new direction to controversies that will call out the best effort of the leading thinkers of our time.

Mr. Spencer has continued his exposition in a chapter to be appended to the volume of Sociology, of which we give in the present number of the Monthly the first installment. To those who are solicitous about his breaking down mentally, we commend the perusal of this paper, and the conclusion of it, which will appear next month. Having disposed in the volume of Mr. Max Müller and his followers, who were overdoing the myth-business, he now takes up the social doctrines of Sir Henry Sumner Maine. This able writer maintains a theory of social development in which the starting-point is the patriarchal system. Mr. Spencer holds that this view is philosophically defective, as it assumes a certain social condition without accounting for it, by investigating the anterior and still lower conditions of social relation. Each one will be his own judge, after reading the argument, as to its validity against Sir Henry Maine's view; we call attention to it here only for the benefit of those who are concerned about the truth of Mr. Conway's statement.

LITERARY NOTICES.

Six Lectures on Light. Delivered in America in 1872–'73. By John Tyndall, D. C. L., LL. D., F. R. S. Second edition. New York: D. Appleton & Co. Pp. 264. Price, $1.50.

Various opinions were passed at the time upon Prof. Tyndall's choice of a subject for his American lectures, and also upon his treatment of it. Some complained

that he had chosen a branch of physics so well settled as that of light, and thought that he ought rather to have entered into some of the exciting phases of modern scientific controversy. Others complained that he dealt with the subject in so elementary a manner, and thought he ought to go into it with a profundity commensurate with his reputation, and such as would afford an adequate excuse for his leaving home and going so far away to instruct a foreign people. For we may just as well acknowledge that there was a great deal of narrowness and illiberality in the view taken of Tyndall's errand, and which was by no means confined to the laity. There was an ill-suppressed jealousy on the part of some of our scientific men, which made them captious in regard to the lectures, and which gave weight and currency to objections that from other sources would have been regarded as frivolous and unworthy of notice. It would have been far easier for Prof. Tyndall to have taken up some of the recent controversial topics, in which the public takes so deep an interest, and read a series of discourses that would have drawn crowds to his lecture-room, instead of encumbering himself with tons of apparatus, and bringing along experienced assistants to make his lectures thoroughly experimental and demonstrative for large popular audiences. But his choice of a subject, and his method of treating it, have been abundantly vindicated. He presented the leading principles of optics in a striking and impressive manner, and as connected and interpreted by the undulatory theory of light, with various lessons and applications in regard to the uses of scientific theory, and the motives of scientific research, which the topic was so well suited to enforce. Tyndall's American lectures form incomparably the best popular exposition of the wave-theory of light to be found in any language, and for this purpose it will long hold its place as a standard book. Accepting the public approval of the work for this purpose, as evinced by the several editions that have been called for, Prof. Tyndall has carefully revised it, made some important additions, and substituted new and superior illustrations, so that the edition which now appears, although faithfully presenting the lectures as they were delivered, has very much the aspect of a new work. He has prefixed to the volume a fine steel engraving, by Mr. Adlard, of Dr. Thomas Young, whose position in modern physics he holds to be only second to that of Newton, and in a full appendix of instructive notes and extracts he has incorporated the addresses of President Barnard, Dr. Draper, President White, and his own remarks, at the Tyndall banquet which followed the close of his lectures in New York. In his preface to the second English edition, now republished here, Prof. Tyndall remarks as follows of the object he had in view in preparing the American lectures: "I have sought to raise the wave-theory of light to adequate clearness in the reader's mind, and to show its power as an organizer of optical phenomena. From what has been recently written on such questions, it is to be inferred that the origin, scope, and warrant of physical theories generally, constitute a theme of considerable interest to thoughtful minds. On these points I have ventured, particularly in the second and third lectures, to state the views which my own reflections have suggested to me. To produce a systematic treatise on light was, of course, quite wide of my aim. My desire, rather, was to throw into a small compass an exposition for which I should have been grateful at a certain period of my own studies. I wished, in the first place, as the prime condition of all satisfactory progress, to clear the reader's mind of all indistinctness regarding elementary facts and conceptions, and to whet incidentally the desire for further knowledge. I wished, moreover, for the sake of that numerous portion of the community who are interested in the material results of science, to trace effects to their causes, by showing how such results receive their primary vitalization from the thoughts of men with no material end in view. The 'Summary and Conclusion,' which might be read as an introduction, is for the most part devoted to this object."

Facts and Fancies about Fish: The New York Aquarium. New York: D. Appleton & Co. Pp. 15.

This little pamphlet is Part I., No. 1, of a series of popular natural history monographs by Mr. W. S. Ward, naturalist of

the New York Aquarium, and contains a very readable and instructive account of the natural objects that are to be seen at that meritorious institution. It is profusely illustrated with capital cuts by Beard, Church, Kelley, and others. It is Mr. Ward's purpose to publish these parts from time to time, as circumstances warrant, with the hope that they will meet with such a demand as will lead to a periodical issue—a hope which will soon be realized if his endeavor meets with the success it deserves.

Essays on Political Economy. By Frédéric Bastiat. English translation revised by David A. Wells. New York: G. P. Putnam's Sons. Pp. 291. Price, $1.25.

Among the modern political writers who have labored to vindicate liberty of trade and to expose the fallacies and economical failures of protection, Bastiat in many respects stands unrivaled. Other men may perhaps have gone deeper into the philosophy of the subject, or contributed more toward the establishment of political economy as a body of scientific principles, but no man has done so much as Frédéric Bastiat to explain and illustrate its truths, and enforce them upon the popular mind. A thorough master not only of the subject but of the art of lucid, attractive, and telling statement, his economical essays are well worth reading, if only for their literary effect. Many writers can make reading pleasant if allowed to choose their themes. Political economy has long been proverbial for its dry, statistical repulsiveness—has long been known as "the dismal science;" but in the hands of Bastiat it is as far as possible from being either dry or dismal. Mr. Wells, the editor of the present work, gives the following account of it in his preface to the American edition:

"This little volume is made up of a selection from the essays of M. Bastiat, that have in a high degree these popular and attractive characteristics; such as a presentation of the nature of capital and interest, and the relation of the two; a discussion, under the title, 'That which is seen and that which is not seen,' of the evils that always result from limiting consideration of the effect of an economic law, tax, or institution, to its immediate visible influence, and ignoring its ultimate consequences, introducing, in so doing, the illustration which has passed into many languages, of 'The Broken Window;' also the questions of 'What is Government?' 'What is Money?' and the nature, object, and function of what is popularly and generally termed 'the law,' without reference to any particular code or statute. So acceptable, indeed, have these short, selected essays proved to the public, that repeated editions of them have been published in France, Belgium, Germany, Italy, England, and the United States; and all that the editor has had to do with the present American edition has been to revise the previous English translation, which was exceedingly imperfect, and in some instances absolutely without meaning. Where the text—which was originally written to meet the condition of affairs in France at the time of the overthrow of the monarchy and the establishment of the republic in 1848—could be changed verbally with advantage to meet the different condition of men, laws, and things, at present existing in the United States, such changes have been made, English names being substituted for French ones, dollars and cents in place of francs and sous, and the like. A few notes pertinent to the subject-matter of the text, and drawn mainly from the recent economic experience of the United States, have also been added."

The Effects of Cross and Self Fertilization in the Vegetable Kingdom. By Charles Darwin, M. A., F. R. S. New York: D. Appleton & Co. Pp. 482. Price, $2.

The name of the author upon this title-page is an assurance that the book is a solid contribution to the advance of that branch of biology which may be named philosophical botany. It is the result of a long series of elaborate, painstaking inquiries into that curious and mysterious field of organic activity, the process of fertilization in plants. The inquiry is hardly popular, and will only have its deepest interest to those who know something of the technicalities of botany. Yet Mr. Darwin has prefixed to the volume an excellent chapter of introductory remarks, which will prove generally intelligible and instructive; and there are but few who will read this chapter and not be lured forward by the attractive and fascinating import of the discussion. The author also adds a very important chapter of general results, in which he states the practical bearing of the inquiry as respects the art of the agriculturist and horticulturist. His discussion is at the basis of the problem and the intelligent practice of breeding. He furthermore points out its great theoretical significance to the scientific inquirer, who aims to go as

deep as possible into the question of Nature's economy in continuing, diversifying, and giving stability to the course of life upon our globe.

An Alphabet in Finance. A Simple Statement of Permanent Principles and their Application to Questions of the Day. By Graham McAdam. New York: G. P. Putnam's Sons. Pp. 210. Price, $1.25.

"This little book," we are told in the preface, "was written as a political duty;" and it would be a blessing to long-suffering listeners and readers if every one who feels a "call" to preach or to write was as well fitted for the task he undertakes as Mr. McAdam. He has succeeded in treating the elementary principles of finance briefly and at the same time clearly, simply, and effectively; and his discussion of the commoner fallacies and often-repeated stock arguments of the inflationists is so good, that it is to be hoped the book will find a circulation among them. The chapters on "Money a Creation of Government," "Pure Credit Money," "What is a Specie Basis?" "Banking"—all brief—are models of statement in their way. Although the author apparently accepts Mr. Jevons's views as to the word *value*, the somewhat ambiguous way in which he uses that term makes the chapter on "The Qualities of Gold for Money" slightly obscure, which is to be regretted, for much of the success of inflation arguments is rooted in the hazy notions concerning what is called the *value* of gold. We would call the author's attention to the statement on page 130, that "$4.444 still remains by custom the nominal par" (of exchange), the fact being that the nominal and real par have been in agreement, at $4.866, both by usage and United States statute for two years or more.

Report of the Geological Survey of Indiana, 1875. By E. T. Cox, State Geologist. Pp. 599. With Maps and Plates.

During the year 1875 the general work of the survey of Indiana was carried on in nine counties: Vigo, Huntington, Jennings, Ripley, Orange, Vanderburgh, Owen, Montgomery, and the southeastern part of Clay. A special reconnaissance was made of the coal-measure rocks of Putnam County; also a special hydrographic survey of some of the lakes in the northern portion of the State. Besides the results of these researches, the report contains observations on fossil marine plants from the coal-measures, by Mr. L. Lesquereux, and a catalogue of the Wabash Valley flora, by Dr. J. Schenck.

Ivanhoe. By Sir Walter Scott. Also Our Mutual Friend. By Charles Dickens. New York: Holt & Co. Pp. 350. Price, $1.

These little volumes belong to the "Condensed Classics" series. The text is absolutely identical with the original works, except that much of the less essential matter of the latter has been omitted. If any one thinks an acquaintance with all the leading writers of his language to be necessary, he *must* resort to condensations like this. Life is not long enough to enable a man to read our entire "polite literature" through.

Annual Reports of the Zoölogical Society of Cincinnati, for the years 1874–'75–'76. Cincinnati: printed for the Society.

It is to be regretted that an enterprise containing so much spirit should not as yet have proved a pecuniary success. The following is interesting: "In Europe there are now [1874] in operation, or in process of construction, more than eighty zoölogical gardens, and, almost without exception, they are profitable, and in some cases largely so. The experience in Philadelphia is encouraging, while that of the garden in San Francisco is . . . . marvelous." Strange that the last report contains no list or statement of the animals!

David and Anna Matson. By Abigail Scott Duniway. Pp. 194. With Illustrations. New York: S. R. Wells & Co. Price, $2.

Inasmuch as it does not lie within our province to estimate the value of works of the imagination, we will only say of this volume that its theme is the "tender passion," in one of its many phases; that the verses are smooth and musical enough, and that the mechanical make-up of the book is admirable as regards print, paper, and binding.

Qualitative Chemical Analysis. A Guide to the Practical Study of Chemistry and of the Work of Analysis. By Silas H. Douglas and Albert B. Prescott, of the University of Michigan. New York: D. Van Nostrand. Second edition, revised. Pp. 254. Price, $3.50.

This excellent work has grown out of the exigencies of chemical teaching. In its earliest form it appeared in 1864, and passed through several editions. It was intended to be used, with Fresenius's "Manual of Qualitative Analysis," as a guide to the experimental study of substances to be made in connection with analysis, but beyond its immediate requirements. It is now revised and enlarged so as of itself to answer the needs of the student, and relieve him from the necessity of obtaining more than one text-book for inorganic qualitative work. Its aim is stated to be, "to aid the student in gaining an accurate acquaintance with the facts whereby analyses are made; and a clear understanding of the coördination of these facts—the principles of analysis—has been the chief object of this work. It is the result of experience in the constant endeavor to prevent habits of automatic operation and of superficial observation in analysis." Various improvements in the work are pointed out in the preface to the new edition, which have been arrived at by the experience of the last ten years, and which bring the volume up to the requirements of the times.

The Chemist's Manual. A Practical Treatise on Chemistry, Quantitative and Qualitative Analysis, Stoichiometry, Blowpipe Analysis, Mineralogy, Assaying, Toxicology, etc. By Henry A. Mott, Jr., E. M., Ph. D. New York: D. Van Nostrand. Pp. 625. Price, $6.

This work is designed not for popular reading, but for practical students of chemistry, and will answer the purpose of a kind of condensed library of technical information, in which the ordinary text-books are deficient. Compiled by a working student, from the needs of his own experience, it cannot fail to be useful to others in similar circumstances, who will find the labor here done to their hand which they would otherwise have to do for themselves. The author has prepared the work on the principle that every scientific man "should compile his own pocket-book, as he proceeds in study and practice, to suit his particular business." Having accumulated from time to time a large number of valuable notes, tables, and chemical data, which became too voluminous to be carried in the pocket, he then decided to extend, systematize, and publish them. Dr. Charles F. Chandler, Professor of Chemistry in the Columbia College School of Mines, introduces the work by a brief preface, in which he says:

"This carefully-prepared 'Manual' of Dr. Mott will prove especially valuable as containing a judicious selection of the most important methods, most of which have been tested by laboratory experience, and found to give satisfactory results. These are presented in a concise form, with reference to original authors. The numerous tables of constants will also be found of great value. This work will possess a special value for the student and laboratory-worker, and will serve as a useful reference-book for the general scientific reader."

Mr. Van Nostrand has got the work out in excellent style, and we have only to make a small complaint of the inartistic monotony of the page-headings, which simply reproduce the title of the book, without giving any guidance to its successive subjects and the variety of its contents.

The Microscopist. A Manual of Microscopy and Compendium of the Microscopic Sciences, with 205 Illustrations. By J. H. Wythe, A. M., M. D., Professor of Microscopy and Biology in the Medical College of the Pacific, San Francisco. Philadelphia: Lindsay & Blakiston. Pp. 259. Price, $4.50.

Dr. Wythe's manual first appeared twenty-five years ago, and he now issues the third edition, rewritten and greatly enlarged. In regard to his object in preparing the volume, the author says: "It is proposed in this treatise to give such a *résumé* of microscopy as shall enable the student in any department to pursue original investigations with a general knowledge of what has been accomplished by others. To this end a comprehensive view of the necessary instruments and details of the art, or what the Germans call technology, is first given, and then a brief account of the application of the microscope to various branches of science, especially considering the needs of physicians and students of medicine." The sciences here referred to are

micro-mineralogy, micro-chemistry, biology, histology, and pathological histology. The work is clearly written, and its matter presented systematically and in very judicious proportions. It contains a great number of beautifully-colored plates, which will prove helpful to the student. In an introductory chapter on the history and importance of microscopy, Dr. Wythe points out the many ways in which this art has proved useful to man in recent times. The following suggestion, however, we had not met with before, and we trust it will incite religious people to buy microscopes and learn to use them: "Even theology has its contribution from microscopy. The teleological view of Nature, which traces design, receives from it a multitude of illustrations. In this department the war between skeptical Philosophy and Theology has waged most fiercely; and if the difference between living and non-living matter may be demonstrated by the microscope, as argued by Dr. Beale and others, Theology sends forth a pæan of victory from the battlements of this science."

Michigan Board of Health. Fourth Annual Report (1876). Pp. 250. Lansing: W. S. George & Co. print.

In addition to the journal of the proceedings of the board, and sundry details of administration, we have here a great deal of matter of general interest: such as statistics of diseases, remarks on illuminating oils, studies of typhoid fever, etc. Among the more voluminous essays, we may mention papers on means of escaping from public buildings in case of fire, vaccination, scarlet fever, criminal abortion, water and water-supply, ventilation of railroad-cars, etc.

Report of the Commissioners of Education for the Year 1875. Pp. 1,189. Washington: Government Printing-Office.

In the personal report of Commissioner Eaton, which occupies the first 170 pages of this volume, is found an instructive retrospect of the history of popular education in this country, together with a general review of the present status of primary and superior instruction, both in the United States and in other countries; then follow voluminous abstracts of the reports of school officers throughout the States and Territories of the Union; and, finally, we have 22 tables of school statistics, giving information with regard to such matters as normal schools, higher schools for women, colleges, scientific schools, public libraries, museums of art and natural history, institutions for the blind, deaf and dumb, and idiots, educational benefactions, etc. The value of the information here conveyed is no doubt very considerable, and it is much enhanced by the addition of a good index.

How to Camp Out. By John M. Gould. New York: Scribner, Armstrong & Co. Price, $1.

This is the best work of the kind ever published. Mr. Gould is the author of a "Regimental History of the War," which received the highest commendation from the New York *Nation* and *Evening Post*. He has camped in every way, and, being a man of the keenest observation and possessed with the orderly faculty of noting down everything, has given in this book advice and suggestion of the greatest value to those who go on camping or tramping expeditions. Sound information is given regarding food, clothing, boots and shoes, knapsacks, tents, and huts of various kinds, with valuable hygienic advice from Dr. Elliott Coues's writings. A pleasant vein of humor runs through its pages; and to those who never stir out of the city, the book will be found entertaining as well as camp-provoking.

SPENCER'S PRINCIPLES OF SOCIOLOGY.

The following notice of this important work is from the review in the London *Examiner*: "The appearance of Mr. Spencer's first volume on 'The Principles of Sociology' will be a matter of rejoicing to that large and growing number of readers whose minds have been deeply impressed and roused to new reflection by the writer's masterly exposition of the philosophy of evolution. This feeling of joy will only be tempered by the regret which Mr. Spencer's readers will certainly experience on learning, from a notice appended to the volume, that disturbed health has obliged him to desist when about to write certain conclud-

ing chapters to this present volume, and that, in his opinion, 'it may be some time—possibly months—before he is able to resume work at his ordinary, slow rate.' Still, this regret should not unduly depress us, seeing that we have now in our hands a bulky volume of over 700 pages, in which the author lays down the principal foundation-lines of his scientific structure. Most of Mr. Spencer's admirers, perhaps, have looked forward to the doctrine of social evolution as the most valuable and interesting result of the author's labors. It is quite natural, indeed, that many, to whom the unfamiliar conceptions of biology and the abstruse subtilties of psychology are somewhat repellent, should look forward to the promised exposition of sociology, with its more familiar ideas of industry, religion, government, etc. To this it may be added that, just now, there is a large concentration of scientific interest on all historical problems, and many who were indifferent to the first principles of matter and motion will look with eagerness into the present volume for its theory of social progress. It may at once be said that all who have anticipated this work will find in it ample intellectual material of the most interesting sort. The author here takes us far enough to enable us to see how his previous volumes have been leading up to a clear and scientific conception of society and its laws—far enough, too, for us to discern the revolution which the theory of evolution is to effect in many current notions respecting social phenomena. . . .

"Mr. Spencer's theory of primitive ideas seems to us so much the most important element in the volume that we have dwelt on it at length, to the neglect of the other parts. Of what remains, only a very few words can be said. After completing his account of the data of psychology, the author passes to his Second Part, which has for its theme 'The Inductions of Sociology.' Under this head Mr. Spencer discusses the nature of society as an organism, the ideas of social growth, social structures and functions, and the division of the social organism into three systems of organs, namely, the sustaining, the distributing, and the regulating, answering to those of digestion, circulation, and nervous coördination, in the individual organism. The analogy between a society and a bodily organism is worked out with remarkable ingenuity, according to the sketch given by the author in the popular introduction to sociology already alluded to. Mr. Spencer succeeds, we think, in establishing the closeness of this similarity, and, what is more, in showing how it arises from the fundamental similarity of the processes of evolution underlying individual and social growth. Thus, for example, the curious analogy in the distributing systems of the two kinds of organism between the up and down lines of railway and the veins and arteries, is seen, on reflection, to be something more than an accidental coincidence. At the same time, Mr. Spencer appears to us to have become more clearly aware of the limits of this analogy, and of the circumstances which mark off social aggregates from single, living organisms.

"After thus determining the data and leading principles of sociology, Mr. Spencer proceeds, in his Third Part, to deal with social phenomena themselves—that is to say, the movements or processes which make up social development. He begins with the domestic relations, the account of which brings the volume to a close. We have no space left to follow the author in his interesting review of the gradual development of monogamy out of the primitive relations of the sexes. His views on the nature of marriage without the tribe and marriage within the tribe (exogamy and endogamy), of polyandry, and polygamy, and of their relations of coexistence and sequence, rest in part on the researches and conclusions of writers like Mr. McLennan, while in some important particulars they deviate from this writer's theories. It strikes us that Mr. Spencer here exhibits an increased power of seizing the many influences which contribute to a complex result. The highly-interesting character of this part, as of the whole volume, makes us look forward to the continuation of this work on 'Sociology,' which, we strongly suspect, to judge by the little progress already made, is going to be much more voluminous than the works on 'Biology' and 'Psychology.' May the author's health speedily allow him to carry forward his great enterprise!"

PUBLICATIONS RECEIVED.

The Poultry Yard and Market: a Practical Treatise on Gallinoculture, and Description of a New Process for hatching Eggs and raising Poultry. By Prof. A. Corbett. New York: Orange Judd & Co. 1877. Pp. 96. Price, 50 cents.

Shade-Trees, Indigenous Shrubs, and Vines. By J. T. Stewart, M. D. And Insects that infest them. By Miss Emma A. Smith. Peoria: *Transcript* Co. print. 1877. Pp. 55.

The People *vs.* Daniel Schrumpf; Misdemeanor, Adulteration of Milk; Argument of W. P. Prentice, Counsel to the Board of Health, for the Prosecution. New York: J. F. Trow & Son print. 1877. Pp. 32.

Coördinate Surveying. By Henry F. Walling, C. E. Published by the American Society of Civil Engineers. 1877. Pp. 19, Three Plates.

Religion and Science; The Psychological Basis of Religion considered from the Standpoint of Phrenology. A Prize Essay. New York: S. R. Wells & Co. 1877. Pp 35. Price, 20 cents.

On Some Derivatives of Diphenylamine. By Dr. P. Townsend Austen. Reprint from *American Journal of Science and Arts*. Pp. 11.

Second Annual Report of the Inspector and Assayer of Liquors to the Commonwealth of Massachusetts. By Prof. J. F. Babcock. Boston: Albert J. Wright print. 1877. Pp. 39.

On the Ethers of Uric Acid; Contributions from the Laboratory of Harvard College. By H. B. Hill. Reprinted from *American Journal of Science and Arts*. Pp. 11.

Lubrication. By Prof. R. H. Thurston. Reprinted from the *Polytechnic Review*. Pp. 4.

Note on the Sensation of Color. By C. S. Peirce. Reprint from *American Journal of Science and Arts*. Pp. 5.

Publications of the Cincinnati Observatory, Nos. 2, 3. Mitchel's Micrometrical Measurements of Double Stars. Pp. 18 and 34.

Laboratory Notes from the University of Cincinnati. By F. W. Clarke. Reprint from *American Journal of Science and Arts*. Pp. 6.

History of the Discovery of the Circulation of the Blood. By W. J. Conklin, M. D. Reprinted from Ohio *Medical and Surgical Journal*. Pp. 14.

On Puerperal Septicæmia. By J. W. Underhill, M. D. Cincinnati: Aldine Printing-Works. 1877.

Field and Forest; a Monthly Journal devoted to the Natural Sciences. Edited by Charles R. Dodge. Vol. II., Nos. 7, 8, 9, and 10. Price $1 a year.

The Development of the Animal Kingdom; a Paper read at the Fourth Meeting of the Association for the Advancement of Women. By Graceanna Lewis. Nantucket: Hussey & Robinson print. 1877. Pp. 21.

Monthly Reports of the Kansas State Board of Agriculture for February and March, 1877. By Alfred Gray, Secretary. Topeka.

Transactions of the Wisconsin Academy of Sciences, Arts, and Letters. Vol. III. 1875-'76. Madison: E. B. Bolen print. Pp. 269.

Van Nostrand's Science Series. No. 28: Transmission of Power by Wire Ropes. By Albert W. Stahl, M. E. Pp. 124. No. 29: Steam Injectors, their Theory and Use. By M. Léon Pochet. Pp. 79. New York. 1877. Price, 50 cents each.

Strength and Calculation of Dimensions of Iron and Steel Constructions. By J. J. Weyrauch, Ph. D. New York. 1877. Pp. 112, with Four Folding Plates. Price, $1.

Linear Perspective. Part I. By F. R. Honey. New Haven, Conn.: Judd & White. 1877. Pp. 35, Nine Plates. Price, $1.25.

Report of the Board of Health of the City and Port of Philadelphia for the Year 1875. Pp. 351.

United States Geographical Surveys west of the One Hundredth Meridian. Appendix JJ of the Annual Report of the Chief of Engineers for 1876. By Lieut. George M. Wheeler. Washington: Government Printing-Office. Pp. 343, accompanied by Seven Topographical Atlas Sheets.

Report of the Secretary of the Navy. 1876. Pp. 336.

Annual Report of the Chief Signal Officer to the Secretary of War, for 1876. Pp. 509, with numerous Weather Maps.

POPULAR MISCELLANY.

Proposed Scientific Expedition around the World.—For some months Mr. James O. Woodruff, of Indianapolis, has been busily engaged in organizing a "scientific expedition around the world," the object of which is to visit points of general and special interest, to study architecture, archæology, geology, and the fauna and flora of new or little known localities, and to make collections and studies in natural history generally.

It is proposed to start from New York some time next fall, in a steamship of a thousand tons, officered by experienced men from our navy, and fitted with all the appliances necessary for such an expedition. Ten scientific professors, selected from the faculties of our leading universities, are to go along in the capacity of teachers, giving lectures and instruction in the various subjects of study.

The island of Marajo, at the mouth of the Amazon, Valparaiso, some of the less known islands of the Central Pacific, New Guinea, Borneo, Ceylon, and Alexandria, are a few of the more prominent points it is proposed to visit; the ship returning by the way of France and England. Inland excursions, for the purposes of exploration and the collection of specimens, will be a feature of the expedition. Eighty students can be accommodated. The trip is expected to consume two years, and will cost each student, according to published estimates, about $5,000.

Fruit-Farming in England.—The home-supply of fruit in England being very inadequate to the demand, foreign fruit has to be imported in enormous quantity. Hence the price of fruit is very high, and the great

mass of the population have to deny themselves this wholesome form of nutriment. The London Society of Arts has undertaken the investigation of the question of fruit-growing, and is laboring to awaken a popular interest in the matter. In this country fruit is cheap and abundant, yet many of the suggestions made on the other side of the Atlantic would not be out of place even here. In one of the papers read before the Society of Arts, it is stated that only 40,000 acres of land are set apart in England for market-gardens. Considering what enormous crops of fruit are obtained from this inconsiderable acreage, how shall we estimate the product of waste lands were they to be cultivated? The market-gardens, as we have seen, cover less than 60 square miles; but the railway embankments represent about 200 square miles of land, one-third of which, at least, could be used for the cultivation of fruit. The little plots of ground attached to cottages in the country and in villages and suburban districts might also be utilized for fruit-growing. Roadsides in the country might also be cultivated profitably. The prospect of success in this effort at enlarging the area of fruit-culture in England is not very encouraging, owing to the unthriftiness of the people. In this respect they compare very unfavorably with their neighbors, the French.

Frequency of Color-Blindness.—There is some reason for believing that writers on "color-blindness" have in many instances exaggerated with regard to the frequency of its occurrence. Thus it has been stated as a fact that no less than ten per cent. of the railroad engine-drivers in Sweden are unable to announce properly the color of the signal-lamps, owing to color-blindness. Mr. Herbert W. Page, surgeon to the London and Northwestern Railway, is of the opinion that, so far from being common, this affection is extremely rare. He cites the testimony of three railway examining surgeons in support of his views. One of these, who in the course of twenty-five years had examined many hundreds of men, writes that color-blindness "is of excessive rarity;" another "has not found it common;" while a third, a surgeon of long experience, writes that he has met with "only three cases of well-marked color-blindness" among many hundreds examined by him. In 800 men examined by Mr. Page himself, not one instance of true color-blindness was found. Similar testimony is given by Dr. Macaldin, of the Midland Railway.

How, then, are we to account for the positive statements of other writers who assert the extreme frequency of this affection? In very many cases ignorance of the *names* of colors is, doubtless, mistaken for inability to distinguish between colors themselves. Then, many persons are hesitating and slow in their recognition of colors. "Green may be spoken of as blue by one, red as green by another, and the name persisted in till the man be asked to compare the one before him with some familiar color, as the grass or sky, when his mistake will be recognized at once. I cannot help thinking," adds Mr. Page, "that such cases as these have often been mistaken as instances of color-blindness. It certainly is within my own experience, that errors of this kind may creep in unawares *unless time and care be given to the examination of those who are ignorant, stupid, or nervous.*"

Marsh-Fevers.—A substantial addition to our knowledge of the true nature of paludic fevers appears to have been made by Messrs. Lanzi and Terrigi, of Rome. Lanzi has found in the cells of microscopic algæ from the Roman marshes certain dark-green granules, which are most numerous when the plants are farthest gone in decomposition. At length these granules fill the cells, are black under the microscope, and the algæ emit an offensive odor. In the Campagna marshes are formed in winter, which in spring develop algæ abundantly. In summer the water disappears, and the algæ then putrefy, the ground afterward growing phanerogamous plants. Toward the fall of the year the algæ in the parts still covered with water also die, and the slime at the bottom of the marshes contains quantities of the dark granules. The latter may also arise from other plants in the state of decay, even where there are no marshes. Lanzi regards these granules as a sort of ferments. Now, the pigment-granules found in the liver and spleen of individuals suffering from malaria have quite similar properties to

those ferment-granules, and they can be developed quite similarly. M. Terrigi has specially devoted himself to the means of disinfection, which may prevent the decaying process and development of the granules; he found chloride of lime, lime, and chloral, the most efficacious. With aspirators and air-filtering apparatus he ascertained that the germs rose to a height of fifty centimetres (about twenty inches) above the marsh-bottom, where they could easily be carried away by the winds. M. Terrigi found the "malaria-melanin" (as they call it) abundant in the liver and spleen of Guinea-pigs that had breathed the marsh-air for some time.

How the Chinese go a-Fishing.—Under the title "Fishing Extraordinary" a writer in *Chambers's Journal* describes various singular devices used in different countries for catching fish. Some portions of the narrative are calculated to put a strain upon the credulity of the reader, as, for instance, when we are informed that "the lakes and rivers of China, and especially of the north, are so abundantly stocked with fish, that in some places the men called fish-catchers make their living by actually seizing and drawing them out with their hands." If any of our readers should happen to dwell in the vicinity of such fish-abounding streams, they will be pleased to learn how these fish-catchers set about their work. Here is the *modus operandi:* The man goes into the water, and proceeds, half walking, half swimming, raising his arms above his head and letting them drop, striking the surface with his hands. Meanwhile his feet are moving on the muddy bottom. Presently he stoops with a rapid dive and brings up a fish in his hand. His object in striking the surface is to frighten the fish, which, when alarmed, sink to the bottom; then the naked feet feel them in the mud, and, once felt, the practised hand secures them in a moment.

Another Chinese method of fishing described by this writer is very ingenious. It is usually practised at night, and depends upon a peculiar power which a white screen, stretched under the water, seems to possess over the fishes, decoying them to it and making them leap. A man sitting in the stern of a long, narrow boat, steers her with a paddle to the middle of a river, and there stops. Along the right-hand side of his boat a narrow sheet of white canvas is stretched; when he leans to that side it dips under the surface, and, if it be a moonlight night, gleams through the water. Along the other side of the boat a net is fastened, so as to form a barrier two or three feet high. The boatman keeping perfectly still, the fish, attracted by the white canvas, approach and leap, and would go over the narrow boat and be free in their native waters on the other side, but for the screen of netting, which stops them and throws them down before the man's feet.

The Use of Anti-Ferments.—To prevent fermentation, a wine-grower in New Jersey added to a twelve-gallon keg of new wine about one gramme (15½ grains) of salicylic acid, or a very little more than the minimum quantity as given by Neubauer. Soon the wine lost its natural flavor, and acquired a flavor something like that of camphor. A sample of this altered wine having been submitted to Dr. Endemann for examination, he at once referred the new flavor to the presence of salicylic ether. In a communication to the American Chemical Society, Dr. Endemann writes: "The formation of this ether may be understood if we regard the circumstances. The wine was only one year old, and could not be considered ripe and ready for sale, and should therefore have received not the minimum quantity but rather more salicylic acid, to entirely prevent after-fermentation. The quantity, therefore, being insufficient, salicylic acid came in contact with alcohol *in statu nascendi*, which caused this abnormal action. Wine-growers are naturally very suspicious of chemicals, and are therefore very apt to make the same mistake—that is, they prefer to use the minimum quantity; and I should not be surprised if similar experiences had followed the application of this substance in other places."

Determination of Copper.—Mr. J. M. Merrick, of Boston, proposes a new method of determining very small quantities of copper. It is intended as a supplement to Bergeron and l'Hôte's colorimetric test, which fails to

indicate a quantity of copper less than 0.5 milligramme. Mr. Merrick's method consists simply in concentrating to a very small bulk the solution suspected to contain copper, and then depositing the copper, if present, upon platinum, by the battery. He uses for a depositing-cell a very small test-tube, on a foot cut off, so as to give a vessel about one and a half inch deep. Into this is introduced the solution acidified with sulphuric acid, and a platinum anode and cathode—each about an inch long and one-eighth inch or less wide—are hung face to face, and very close together; and, the circuit being completed, very satisfactory deposits of copper are obtained with incredibly minute quantities of the metal. The amounts are determined by the increased weight of the cathode (which is provided with a platinum wire soldered on with gold, by which it can be hooked to a balance) and on the loss of weight of the same after washing with nitric acid. The platinum is polished and heated red-hot before the first weighing, and then gently heated before hanging in the solution. The contrast in color between deposited copper and bright platinum is, of course, striking and characteristic. In this way, 0.1 milligramme of copper may be, the author thinks, safely determined; while for mere qualitative analysis this method may be employed where the amount is even smaller.

Award of the Bigsby Medal to Prof. O. C. Marsh.—Prof. P. Martin Duncan, President of the Geological Society of London, in announcing the award of the Bigsby Medal to Prof. O. C. Marsh for his services in investigating the paleontology of the *Vertebrata*, paid a high but well-merited compliment to the learned Yale professor. Said Prof. Duncan: "He has distinguished himself by studying the fossil remains of nearly every great group of the vertebrata from the palæozoic, cretaceous, and cainozoic strata of the New World. The field of his research has been immense, but it has been very correct; and his descriptive and classificatory paleontological work indicates his effective grasp of anatomical details, and his great power as a comparative osteologist." Prof. Duncan then enumerated in some details the chief lines of research pursued by Prof. Marsh, and was followed by Mr. Hulke, himself a paleontologist, who heartily approved all that had been said by the president with respect to the value of Prof. Marsh's services to paleontology. "These," he said, "are so numerous and important as to mark an epoch in this line of research. The present recognition of the value of his labors will doubtless prove an incentive to fresh work."

What is Moderate Drinking?—The advocates of total abstinence from intoxicating liquors are wont to condemn even a moderate use of stimulating drinks, on the ground that "moderate drinking is the parent of excessive drinking." The *Lancet* questions the correctness of this proposition, but in its negative definition of what is meant by "moderate" drinking the votaries of Bacchus will find very little comfort. "The man," says the *Lancet*, "who begins the day with a 'soda-and-brandy,' has very little respect for his constitution, and if he does not alter his habits, they will alter his health. Odd glasses of beer and glasses of spirit in a forenoon do not come within the range of moderate drinking. That is not moderate drinking which adds fifteen or twenty beats to the pulse, or which flushes the face. Finally, all casual drinking is bad, presumably, and not moderate drinking. The system will not receive food merely as a matter of conviviality, at all sorts of odd hours. Still less will it receive with impunity drink in this way. Drinking which disturbs sleep, either by making it heavy or by driving it away, is not moderate. Moderate drinking is that which consists with a clean tongue, a good appetite, a slow pulse, a cool skin, a clear head, a steady hand, good walking-power, and light, refreshing sleep. It is associated with meals, and is entirely subordinated to more convenient and less objectionable forms of food. That such drinking produces drunkenness, has yet to be proved, as it has yet to be proved to be essential to health."

Retention of Impressions by the Retina.—Does the retina retain in death the image last impressed upon it? That such is the case has been asserted, but hitherto the evidence has not been satisfactory, to say

the least. But recent experiments made by Prof. Kühne, of Heidelberg, appear to show that the image does remain. He took a rabbit and fixed its head and one of its eyeballs at a distance of about five feet from a small opening in a window-shutter. The head was covered for five minutes with a black cloth and then exposed for three minutes to a somewhat clouded mid-day sky. The rabbit was then instantly decapitated; the eyeball which had been exposed was extirpated in yellow light, then opened and instantly plunged into a weak solution of alum. Two minutes after death the second eyeball, without removal from the head, was subjected to exactly the same processes. On the following morning the retinæ of both eyes were carefully isolated, separated from the optic nerve, and turned. They exhibited a nearly square, sharp image, with sharply-defined edges.

Extirpation of our Larger Mammals.—In a paper on the extirpation of our larger indigenous mammals, published in the *Penn Monthly*, Mr. J. A. Allen remarks that the larger, the less sagacious, or the otherwise more easily-captured species, have always been the first to be destroyed. The walrus, being hunted for its ivory and its oil, soon became extinct in the Gulf of St. Lawrence; the bison wholly disappeared east of the Mississippi (south of Wisconsin) prior to the year 1800; the moose and the caribou were early pressed back into the remoter northern forests; and the elk everywhere quickly disappeared before the advancing settlements. Formerly abundant from the Great Lakes nearly to the Gulf coast, its sole survivors east of the Mississippi for the last few decades have been confined to the least frequented parts of the Alleghanies, where few, if any, still survive. Thirty years ago it was abundant over nearly all of the prairies, plains, and mountain valleys of the Great West, where it is now confined within comparatively narrow boundaries, and its present rapid rate of decrease portends its speedy total extirpation south of the forty-ninth parallel. The Virginia deer, once a common denizen of the whole eastern half of the United States, now scarcely exists in New England south of the forests of Maine and Northern New Hampshire, or in New York south or west of the great Adirondack Wilderness, or anywhere in the Middle States away from the mountains. It has also disappeared from a large part of the Atlantic coast-region farther southward, and from the greater part of the area between the Great Lakes and the Tennessee river. The bear, the panther, the gray wolf, and the lynx, have become similarly restricted. The fisher, the marten, and the Canada porcupine, former inhabitants of the northern parts of the northern tier of States, as well as of the Appalachian highlands to or beyond Virginia, have only here and there a few lingering representatives in the least frequented parts of the mountains, and are much more rare than formerly in the forests of Northern New England and the great unsettled region north of the St. Lawrence. The same is true of the beaver, except that it had a much more extended range to the southward, being a former inhabitant of Northern Florida and the middle and northern portions of the Gulf States, and of all the intervening region thence northward.

Psychic Phenomena.—Mr. Sergeant Cox, in a letter to the London *Spectator*, made the assertion that no one who had investigated "psychic phenomena" ever had "come to any other conclusion than that they were real." To this Moncure D. Conway replies as follows:

"I beg to inform that gentleman that I have for more than twenty years, both in the United States and in England, and in the presence of well-known mediums as well as private circles, diligently investigated the subject, and I have never seen any phenomena at all worthy of notice, except such as indicate the audacity of some persons and the weakness of others."

Extending the Meat-Supply.—One of the most enthusiastic hippophagists of Paris, M. Decroix, not content with advocating the use of horse-flesh for food, now would have people eat the flesh of diseased animals. He has made it a practice to eat the flesh of horses killed in his service, which had glanders or farcy, and, whether thoroughly or partially cooked, he found no evil results to his health. Further,

ever since 1861 he has eaten the flesh of all animals that have died within his reach, no matter from what disease. He affirms that one may eat with impunity the flesh, cooked (not putrid), of any of the domesticated animals, no matter what they died of — glanders, typhus, hydrophobia, etc. So far from the flesh of animals which have died naturally having a repugnant appearance or a peculiar flavor, he states that he has placed the two kinds side by side in the same pan and with the same sauce, and, in serving to different persons, many of them connoisseurs, the meat of animals that have died a natural death has invariably been pronounced superior to that from the slaughter-house!

New Test of Death.—The importance of having some readily-applied and indisputable test of the fact of death is apparent, and many are the processes that have been offered to determine it. Nevertheless, such a test appears to be still a desideratum—unless, indeed, we accept that offered by Kappeler. In the course of his researches on the electrical stimulation of dead muscles, Kappeler subjected twenty corpses to the action of various electric currents, noting the times of disappearance of contractility. In persons emaciated by chronic maladies, it disappeared much more rapidly than in well-nourished individuals, or those who had had acute disease. It disappeared seventy-five minutes after death at the quickest, and six and a half hours at the slowest. In cases where a rise of temperature is observed after death electric contractility persists longest. So long as there remains the least flicker of life the contractions continue intact. In the most prolonged faints, in the deepest lethargies, in poisoning by carbonic oxide, chloroform, etc., there is contraction so long as life lasts. But if the muscles make no response to the electrical stimulation, Kappeler pronounces life to be extinct.

Voracity of the Trout.—A correspondent writing from Au Sable Forks, New York, communicates to The Monthly the following very remarkable instance of voracity in a trout: While he and another gentleman were fishing in a stream near the place of his residence, they came to a "long still hole," into which his companion dropped a hook and line, and immediately after pulled up a trout measuring about nine inches. The trout had swallowed the hook, and, in trying to extricate it, the fish's mouth, throat, and stomach, were found to be almost filled with a snake. They pulled the animal out and threw it on the bank; it had evidently been recently killed. "We did not measure the snake," writes our correspondent, "but each of us estimated its length at fourteen inches. We took," he adds, "about a dozen more trout from the same hole, which seemed to show that this enormous meal had not made the trout in the least sluggish, or dulled the edge of his appetite; for if it had, some of the smaller fish would have taken the bait before him."

Deaths from Inhalation of Chloroform.—In communicating to the Cincinnati Academy of Medicine a list of deaths by chloroform occurring in that city and its vicinity, Dr. Charles Anderson recognizes a "strange fatality" attending the use of the drug in Cincinnati. No other city in the United States numbers so many deaths from this cause; yet, perhaps, if all the chloroform casualties of other cities had been duly recorded, Cincinnati would no longer hold this bad preëminence. The author calls attention to a singular anomaly observed in the action of this anæsthetic, viz., that many of those who have died from chloroform have taken it repeatedly, and often for a considerable time, without any unpleasant symptoms, whereas an attempt to give it a short time afterward has proved fatal. Thus one patient, who had taken it frequently during ten years, died from forty drops; another had taken it a hundred times, and had once been under its influence for five hours; the last dose, which was fatal, consisted of an inhalation or two from a chloroformed handkerchief. After citing other similar instances, Dr. Anderson, whose communication we find in the *Clinic*, expresses the opinion that in these cases there exists a sort of floating idiosyncrasy—one that may have hold of a man for an hour or an instant. "It may be on him to-day," adds the author, "and off to-morrow; but if, while under its influence, he inhale the vapor of

chloroform, he is almost sure to die. I was on the point of saying, if he inhale the *slightest* quantity of the vapor of chloroform, it will prove fatal. I am almost convinced that that would not be putting it too forcibly. When you consider the remarkably small quantity given in all the cases, I think you will be inclined to say that there is something in the theory."

NOTES.

Dr. Elliott Coues, U. S. Army, the distinguished naturalist of the Hayden Surveys, and one of the most eminent ornithologists in the country, has just been elected Professor of Anatomy in the National Medical College in Washington. He entered upon its duties in April, and chose for the subject of his inaugural lecture, "Anatomical Science in its Bearings on the Origin of Species and Man's Place in Nature." He took strong grounds for the truth of evolution, and claimed the right to seek and state "the truth of Nature as existing in matter, with no heed to possible results, and without regard to the dictation of dogma, the sensibilities of prejudice, or the fears of ignorance."

The Summer School of Science, inaugurated last year at Bowdoin College, is to be continued this season, the term to commence July 16th and last six weeks. The studies this year will be chemistry, mineralogy, and zoölogy, practical instruction to be given in each, books being employed solely for purposes of reference. The fee for a full course, consisting of any two studies, is $20; for a single study, $12. Neither entrance examination nor recitations will be required.

J. Scott Bowerbank, well known for his studies of the lower forms of marine life, especially the sponges, died at Hastings (England) on the 9th of March, in his eightieth year.

An observed increase of temperature at the Greenwich Observatory during recent years is attributed, by Mr. H. S. Eaton, President of the London Meteorological Society, to the heat imparted to the air by the city of London. He estimates that the heat developed from the present annual consumption of 5,000,000 tons of coal, on the 118 square miles covered by the city, and from all other artificial sources, would suffice to raise the temperature of a stratum of air 100 feet in depth, resting on that area, 2.5° every hour. On account of this influence, he considers the location a bad one for a first-class observatory.

Johann C. Poggendorff, for upward of fifty years editor of the *Annalen der Physik und Chemie*, died in Berlin, January 24th, aged eighty years. His scientific studies were mostly concerned with the phenomena of electricity and magnetism. In 1834 he was appointed Professor Extraordinary of Physics in the University of Berlin, which position he held till his death. His contributions to science are chiefly to be found in the "Transactions" of the Berlin Royal Academy of Sciences.

We learn from the *Milwaukee Sentinel* that the theologians of that locality have arranged a concerted assault upon the conclusions of the biologists, and that paper remarks concerning it, that "the systematic attack arranged by the orthodox preachers of this city on the modern scientific theory of life indicates alarm, and is the first evidence that the evolution theory has met, or is likely to meet, with popular favor." It admonishes them to beware lest they create an interest in the subject, and set people to reading and thinking about it, who, if let alone, would probably pay little attention to it. The chances are that these gentlemen, who have combined to fight biological doctrines from their pulpits, will be the loudest to protest that there is no possible conflict between religion and science.

According to an obituary notice in the *Bulletin*, of Baltimore, the late Ross Winans was the first to prove the feasibility of using anthracite coal as fuel on locomotive-engines. He was also the inventor of the eight-wheel railroad-car.

Mr. John Y. Culyer, in a recent paper read at a meeting of the Association of School Commissioners and City Superintendents held in Albany, advocates the study of industrial and inventive drawing in our public schools, on the ground that, as a large majority of the pupils in these schools are destined for industrial occupations, their studies should be adapted to improvement in this direction. "Upon what," he asks, "does a man's advancement as a workman depend? Upon three things: his readiness in reading the designs of others, his skill with his tools in fashioning the designs of others, and his skill with his tools in fashioning designs of his own. His greatest advancement comes when he is able to do the latter."

A committee of the Ohio College Association has reported in favor of a State Board of Examiners, whose duty it shall be to examine all candidates for college degrees and have the exclusive power of granting the same. This is an important step, and nowhere is such a system more needed than in connection with our medical schools.

The *Scientific Farmer* states that a factory—the first in this country—for making sugar from corn is now in operation at Davenport, Iowa. The product is known as grape or starch sugar, or glucose, and differs from common or cane sugar in containing more oxygen and hydrogen, and in being less sweet and less crystallizable. It is consumed in large quantities by confectioners, who have hitherto been supplied mainly from France and Germany, where it is manufactured from potatoes.

The low-lying coast country of the African Continent bears an evil reputation for unhealthiness, and this reputation is, no doubt, in part well deserved. But the habits of the European residents and traders are to blame for no small portion of the excessive mortality. There is a great deal of truth and good sense in the observation of a recent traveler, that even in the deadly atmosphere of the western coast the chances of ill health might be materially reduced, if Europeans would make only a judicious use of stimulants, eat good, well-cooked food, avoid undue exposure to the weather, and shun idleness.

Dr. Edward Rae, a veteran arctic explorer, complains that the pemmican prepared for the sled-parties of the British Polar Expedition was salted, and that their stores included salt bacon; while the stock of preserved potatoes was insufficient, and condensed milk, an excellent antiscorbutic, was not even thought of. The experience of this expedition goes to show that alcohol furnishes no protection against the effects of excessive cold, but, on the contrary, increases the liability to frost-bite.

From interesting statistics concerning suicide in London and New York, given in a late number of the *Lancet*, we learn that self-murder is more frequent in winter than in summer; that, in proportion to population, nearly twice as many kill themselves in New York as in London, the excess being mainly due to the large number of suicides among the Germans; and that drowning, hanging, and cut-throat, are the favorite methods of taking off in London, while poison and the pistol are preferred in New York.

The Fish Commissioners of Pennsylvania state in their report that the Susquehanna River, from its mouth to the head-waters of both the Juniatas, is now full of black bass. The same may be said of both the West and North Branches for considerable distances above their confluences. The Delaware, too, along the entire State border, is equally supplied, while several of its Pennsylvania branches are filling by degrees.

The Commission appointed to inquire into the workings of the English Meteorological Department have recommended an increase of nearly one-third in the annual grant for meteorological purposes, and the appointment of a Meteorological Council, to administer the grant in place of the committee of the Royal Society that has heretofore had it in charge.

The common article beeswax, according to the *American Journal of Pharmacy*, is frequently much adulterated; paraffine, resin, stearine, Japan wax, or mixtures of two or more of these, being the substances usually employed.

According to the "Seventh Annual Report of the Fish Commissioners of New Jersey," the yield of fish from the waters of the State was last year much below the average of previous years. This was notably the case with shad-fishing in the Delaware. One of the causes given for this decrease is the introduction of black bass into the river, where they have multiplied immensely, and are believed to devour large numbers of the young shad.

Dr. C. W. Siemens, President of the Iron and Steel Institute of Great Britain, in his recent inaugural address, strongly urged the necessity for a more extended system of technical education, as the only true basis for national prosperity in the industrial arts. The nations of the Continent of Europe, he declared, were ahead of England in this respect; what little the latter had done having been more a measure of self-defense made necessary by the increasing competition from abroad, rather than the growth of an enlightened public policy, of which the country stands greatly in need.

An interesting discovery of animal remains was recently made in a cave near Santander, in Northern Spain. The discoverers, Messrs. O'Reilly and Sullivan, describe the cavern as an enlarged joint or rock-fissure, into which the entire carcasses, or else the living animals, had been precipitated. Prof. A. Leith Adams has identified among these remains numerous portions, including teeth, of *Elephas primigenius*, which is important as furnishing the first instance of the occurrence of that animal in Spain.

If the mirror of a laryngoscope be moistened with glycerine, the water-vapor in the air expired by the subject under examination will not dim its surface, being dissolved in the glycerine. The *Polytechnic Review* points out the benefit to be derived from a similar application of glycerine to the lenses of astronomical telescopes, by preventing the formation on them of dew, which often disturbs observations.

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ON THE EVOLUTION OF THE FAMILY.

By HERBERT SPENCER.

II.

AND here we come in face of the fact before obliquely glanced at, that Sir Henry Maine's hypothesis takes account of no stages in human progress earlier than the pastoral or agricultural. The groups he describes as severally formed of the patriarch, his wife, descendants, slaves, flocks, and herds, are groups implying that animals of several kinds have been domesticated. But before the domestication of animals was achieved, there passed long stages stretching back through prehistoric times. To understand the patriarchal group, we must inquire how it grew out of the less-organized groups that preceded it.

The answer is not difficult to find if we ask what kind of life the domestication of herbivorous animals entailed. Where pasture is abundant and covers large areas, the keeping of flocks and herds does not necessitate separation into very small clusters: instance the Comanches, who, with their hunting, join the keeping of cattle, which the members of the tribe combine to guard. But where pasture is not abundant, or is distributed in patches, cattle cannot be kept together in great numbers; and their owners consequently have to part. Naturally, the division of the owners will be into such clusters as are already vaguely marked off in the original aggregate: individual men with such women as they have taken possession of, such animals as they have acquired by force or otherwise, and all their other belongings, will wander hither and thither in search of food for their sheep and oxen. As already pointed out, we have, in prepastoral stages, as among the Bushmen, cases where scarcity of wild food necessitates parting into very small groups; and clearly when, instead of game

and vermin to be caught, cattle have to be fed, the distribution of pasturage, here in larger, there in smaller oases, will determine the numbers of animals, and consequently of human beings, which can keep together. In the separation of Abraham and Lot we have a traditional illustration.

Thus recognizing the natural origin of the wandering family group, let us ask what are likely to become its traits. We have seen that the regulating system of a society is evolved in the course of conflicts with environing societies. Between pastoral hordes which have become separate, and in course of time alien, there must arise, as between other groups, antagonisms: caused sometimes by appropriation of strayed cattle, sometimes by encroachments upon grazing areas monopolized. But now mark a difference. In a tribe of archaic type, such ascendency as war from time to time gives to a man who is superior in strength, will, or cunning, commonly fails to become a permanent headship, since his power is regarded with jealousy by men who are in other respects his equals. It is otherwise in the pastoral horde. The tendency which war between groups has to evolve a head in each group, here finds a member prepared for the place. Already there is the father, who at the outset was, by right of the strong hand, leader, owner, master, of wife, children, and all he carried with him. In the preceding stage his actions were to some extent under check by other men of the tribe; now they are not. His sons could early become hunters and carry on their lives independently; now they cannot.

Note a second difference. Separation from other men brings into greater clearness the fact that the children are not only the wife's children, but his children; and further, since among its neighbors his group is naturally distinguished by his name, the children spoken of as members of his group are otherwise spoken of as his children. The establishment of male descent is thus facilitated. Simultaneously there is apt to come acknowledged supremacy of the eldest son: the first to give efficient aid to the father, the first to reach manhood, the first likely to marry and have children, he is usually the one on whom the powers of the father devolve as he declines and dies. Thus the average tendency through successive generations will be for the eldest male to become head of the increasing group, alike as family ruler and political ruler—the patriarch.

At the same time industrial coöperation is fostered. Savages of the lowest types get roots and berries, shell-fish, vermin, small animals, etc., without joint action. Among those who, having reached the advanced hunting stage, capture large animals, a considerable combination is implied, though of an irregular kind. But on rising to the stage in which flocks and herds have to be daily pastured and guarded, and their products daily utilized, combined actions of many kinds are necessitated; and under the patriarchal rule these become

regularized by apportionment of duties. This coördination of functions, and consequent mutual dependence of parts, conduce to consolidation of the group as an organic whole. Gradually it becomes impracticable for any member to carry on his life by himself, deprived not only of the family aid and protection, but of the food and clothing yielded by the domesticated animals. So that the industrial arrangements conspire with the governmental arrangements to produce a well-compacted aggregate, internally coherent and externally marked off definitely from other aggregates.

This process is furthered by disappearance of the less developed. Other things equal, those groups which are most subordinate to their leaders will succeed best in battle. Other things equal, those which, submitting to commands longer, have grown into larger groups, will thus benefit. And other things equal, advantages will be gained by those in which, under dictation of the patriarch, the industrial coöperation has been rendered efficient. So that, by survival of the fittest among pastoral groups struggling for existence with one another, those which obedience to their heads and mutual dependence of parts have made the strongest will be those to spread; and in course of time the patriarchal type will thus become well marked. Not, indeed, that entire disappearance of less-organized groups must result; since regions favorable to the process described facilitate the survival of smaller hordes, pursuing lives more predatory and less pastoral. So that there may simultaneously grow up larger clusters which develop into pastoral tribes, and smaller clusters which subsist mainly by robbing them.

Mark next how, under these circumstances, there arise certain arrangements respecting ownership. The division presupposed by individualization of property cannot be carried far without appliances which savage life does not furnish. Measures of time, measures of quantity, measures of value, are required. When from the primitive appropriation of things found, caught, or made, we pass to the acquisition of things by barter and by service, we see that approximate equality of value between the exchanged things is implied; and in the absence of recognized equivalence, which must be exceptional, there will be great resistance to barter. Among savages, therefore, property extends but little beyond the things a man can procure for himself. Kindred obstacles occur in the pastoral group. How can the value of the labor contributed by each to the common weal be measured? To-day the cowherd can feed his cattle close at hand; to-morrow he must drive them far and get back late. Here the shepherd tends his flock in rich pasture; and in a region next visited the sheep disperse in search of scanty food, and he has great trouble in getting in the strayed ones. No accounts of labor spent by either can be kept, and there are no current rates of wages to give ideas of their respective claims to shares of produce. The work of the daughter or

the bondwoman, who milks and who fetches water, now from a well at hand and now from one farther off, varies from day to day; and its worth, as compared with the worths of other works, cannot be known. So with the preparation of skins, the making of clothing, the setting up of the tents. All these miscellaneous services, differing in arduousness, duration, skill, cannot be paid for in money or produce while there exists neither currency nor market in which the relative values of articles and labors may be established by competition. Doubtless a bargain for services rudely estimated as worth so many cattle or sheep may be entered into. But beyond the fact that this form of payment, admitting of but very rough equivalence, cannot conveniently be carried out with all members of the group, there is the fact that, even supposing it to be carried out, the members of the group cannot separately utilize their respective portions. The sheep have to be herded together; it would never do to send them out in small divisions, each requiring its attendant. The milk which cows yield must be dealt with in the mass—could not without great loss of labor be taken by so many separate milk-maids and treated afterward in separate portions. So is it throughout. The members of the group are naturally led into the system of giving their respective labors and satisfying from the produce their respective wants: they have to live as a corporate body. The patriarch, at once family-head, director of industry, owner of all members of the group and its belongings, regulates the labor of his dependents; and, maintaining them out of the common stock that results, is restrained in his distribution, as in his conduct at large, only by traditional custom and by the prospect of resistance and secession if he disregards too far the average opinion.

The mention of secession introduces a remaining trait of the patriarchal group. Small societies, mostly at enmity with surrounding societies, are anxious to increase the numbers of their men that they may be stronger for war. Hence sometimes female infanticide, that the rearing of males may be facilitated; hence in some places, as parts of Africa, a woman is forgiven any amount of irregularity if she bears many children; hence the fact that among the Hebrews barrenness was so great a reproach. This wish to strengthen itself by adding to its fighting-men leads each group to welcome fugitives from other groups. Everywhere, and in all times, there goes on desertion—sometimes of rebels, sometimes of criminals. Stories of feudal ages, telling of knights and men-at-arms who, being ill-treated or in danger of punishment, escape and take service with other princes or nobles, remind us of what goes on at the present day in various parts of Africa, where the dependents of a chief who treats them too harshly leave him and join some neighboring chief, and of what goes on among such wandering South American tribes as the Coroados, members of which join now one horde and now another, as impulse prompts. And

that with pastoral peoples the like occurs, we have direct evidence: Pallas tells us of the Calmucks and Mongols that men oppressed by a chief desert and go over to other chiefs. Occasionally occurring everywhere, this fleeing from tribe to tribe entails ceremonies of incorporation if the stranger is of fit rank and worth—exchange of names, mingling of portions of blood, etc.—by which he is supposed to be made one in nature with those he has joined. What happens when the group, instead of being of the hunting type, is of the patriarchal type? Adoption into the tribe now becomes adoption into the family. The two being one—the family being otherwise called, as in Hebrew, "the tent"—political incorporation is the same as domestic incorporation. And adoption into the family, thus established as a sequence of primitive adoption into the tribe, long persists in the derived societies when its original meaning is lost.

And now to test this interpretation. Distinct in nature as are sundry races leading pastoral lives, we find that they have evolved this social type when subject to these particular conditions. That it was the type among early Semites does not need saying: they, in fact, having largely served to exemplify its traits. That the Aryans during their nomadic stage displayed it is implied by the account given above of Sir Henry Maine's investigations and inferences. We find it again among the Mongolian peoples of Asia; and again among wholly alien peoples inhabiting South Africa. Of the Hottentots, who, exclusively pastoral, differ from the neighboring Bechuanas and Caffres in not cultivating the soil at all, we learn from Kolben that all estates "descend to the eldest son, or, where a son is wanting, to the next male relation;" and "an eldest son may after his father's death retain his brothers and sisters in a sort of slavery." Let us note, too, that among the neighboring Damaras, who, also exclusively pastoral, are unlike in the respect that kinship in the female line still partially survives, patriarchal organization, whether of the family or the tribe, is but little developed, and the subordination small; and further, that among the Caffres, who, though in large measure pastoral, are partly agricultural, patriarchal rule, private and public, is qualified.

It would doubtless be unsafe to say that under no other conditions than those furnished by pastoral life does there arise this family type. We have no proof that it may not arise along with direct transition from the hunting life to the agricultural life. But it would appear that usually this direct transition is accompanied by a different set of changes. Where, as in Polynesia, pastoral life has been impossible, or where, as in Peru and Mexico, we have no reason to suppose that it ever existed, the political and domestic arrangements, still characterized much or little by the primitive system of descent in the female line, have acquired qualified forms of male descent and its concomitant arrangements; but they appear to have done so under pressure of the influences which habitual militancy maintains. We have an indication of

this in the statement of Gomara respecting the Peruvians that "nephews inherit, and not sons, except in the case of the Incas." Still better are we shown it by sundry African states. Among the coast negroes, whose kinships are ordinarily through females, whose various societies are variously governed and most of them very unstable, male descent has been established in some of the kingdoms. The inland negroes, too, similarly retaining as a rule descent in the female line, alike in the state and in the family, have acquired in their public and private arrangements some traits akin to those derived from the patriarchal system; and the like is the case in Congo. Further, in the powerful kingdom of Dahomey, where the monarchy has become stable and absolute, male succession and primogeniture are completely established, and in the less despotically governed Ashantee partially established.

But whether the patriarchal type of family may or may not arise under other conditions, we may safely say that the pastoral life is most favorable to development of it. From the general laws of evolution it is a corollary that there goes on integration of any group of like units simultaneously exposed to forces that are like in kind, amount, and direction; and obviously the members of a wandering family, kept together by joint interests and jointly in antagonism with other such families, will become more integrated than the members of a family associated with other families in a primitive tribe, all the members of which have certain joint interests, and are jointly in antagonism with external tribes. Just as we have seen that larger social aggregates become coherent by the coöperation of their members in conflict with neighboring like aggregates, so with this smallest social aggregate constituted by the nomadic family. Of the differentiations that simultaneously arise, the same may be said. As the government of a larger society is evolved during its struggles with other such societies, so is the government of this smallest society. And as here the society and the family are one, the development of the regulative structure of the society becomes the development of the regulative family structure. Moreover, analogy suggests that the higher organization given by this discipline to the family group makes it a better component of societies afterward formed than are family groups which have not passed through this discipline. Already we have seen that great nations arise only by aggregation and reaggregation: small communities have first to acquire some consolidation and structure; then they admit of union into compound communities, which, when well integrated, may again be compounded into still larger communities; and so on. It now appears that social evolution is most favored when this process begins with the smallest groups—the families: such groups, made coherent and definite in the way described, and afterward compounded and recompounded, having originated the highest societies.

An instructive analogy between social organisms and individual organisms supports this inference. In a passage from which I have already quoted a clause, Sir Henry Maine, using a metaphor which biology furnishes, says: "All the branches of human society may or may not have been developed from joint families which arose out of an original patriarchal cell; but, wherever the joint family is an institution of an Ayran race, we see it springing from such a cell, and, when it dissolves, we see it dissolving into a number of such cells:" thus implying that, as the cell is the proximate component of the individual organism, so the family is the proximate component of the social organism. But in either case this, though generally true, is not entirely true; and the qualification required is extremely suggestive. Low down in the animal kingdom exist creatures not possessing the definite cell-structure—small portions of living protoplasm without limiting membranes, and even without nuclei. There are also certain types produced by aggregation of such *Protozoa;* and, though it is now alleged that the individual components of one of these compound *Foraminifera* have nuclei, yet they have none of the definiteness of developed cells. In types above these, however, it is otherwise: every cœlenterate, molluscous, annulose, or vertebrate animal begins as a cluster of distinct, nucleated cells. Whence it would seem that the unorganized portion of protoplasm constituting the lowest animal cannot, by union with others such, furnish the basis for a higher animal; and that the simplest aggregates have to become definitely developed before they can form larger aggregates capable of much development. Similarly with societies. The tribes in which the family is vague and unsettled remain politically unorganized. Sundry partially-civilized peoples characterized by some definiteness and coherence of family structure have attained corresponding heights of social structure. And the highest organizations have been reached by nations compounded out of family groups which had previously become highly organized.

And now, limiting our attention to these highest societies, we have to thank Sir Henry Maine for showing us the ways in which many of their ideas, customs, laws, and arrangements, have been derived from those which characterized the patriarchal group.

In all cases, habits of life, when continued for many generations, mould the nature; and the resulting traditional beliefs and usages, with the accompanying sentiments, become difficult to change. Hence, on passing from the wandering pastoral life to the settled agricultural life, the patriarchal type of family, with its established traits, persisted, and gave its stamp to the social structures which gradually arose. As Sir Henry Maine says: "All the larger groups which make up the primitive societies in which the patriarchal family occurs, are seen to be multiplications of it, and to be, in fact, them-

selves more or less formed on its model." The divisions which grow up as the family multiplies become distinct in various degrees. "In the joint undivided family of the Hindoos, the stripes, or stocks, which are only known to European law as branches of inheritors, are actual divisions of the family, and live together in distinct parts of the common dwelling;" and similarly in some parts of Europe. In the words of another writer: "The Bulgarians, like the Russian peasantry, adhere to the old patriarchal method, and fathers and married sons, with their children and children's children, live under the same roof until the grandfather dies. As each son in his turn gets married, a new room is added to the old building, until with the new generation there will often be twenty or thirty people living under the same roof, all paying obedience and respect to the head of the family." From further multiplication results the village community; in which the households, and in part the landed properties, have become distinct. And then, where larger populations arise, and different stocks are locally mingled, there are formed such groups within groups as those constituting, among the Romans, the family, the house, and the tribe: common ancestry being in all cases the bond.

Along with persistence of patriarchal structures under new conditions naturally goes persistence of patriarchal principles. There is supremacy of the eldest male; sometimes continuing, as in Roman law, to the extent of life-and-death power over wife and children. There long survives, too, the general idea that the offenses of the individual are the offenses of the group to which he belongs; and, as a consequence, there survives the practice of holding the group responsible and inflicting punishment upon it. There come the system of agnatic kinship, and the resulting laws of inheritance. And there develops the ancestor-worship in which there join groups of family, house, tribe, etc., that are large in proportion as the ancestor is remote. These results, however, here briefly indicated, do not now concern us; they have to be treated of more as social than as domestic phenomena.

But with one further general truth which Sir Henry Maine brings into view, we are concerned—the disintegration of the family. "The *unit* of an ancient society was the family," he says, and "of a modern society the individual." Now, excluding those archaic types of society in which, as we have seen, the family is undeveloped, this generalization appears to be amply supported by facts; and it is one of profound importance. If, recalling the above suggestions respecting the genesis of the patriarchal family, we ask what must happen when the causes which joined in forming it are removed, and replaced by antagonistic causes, we shall understand why this change has taken place. In the lowest groups, while there continues coöperation in war and the chase among individuals belonging to different stocks, the family remains vague and incoherent, and the individual is the

unit. But when the imperfectly-formed families with their domesticated animals, and the family and the society, are thus separate into distinct groups, made identical—when the coöperations carried on are between individuals domestically related as well as socially related, then the family becomes defined, compact, organized; and its controlling agency gains strength because it is at once parental and political. This organization which the pastoral group gets by being at once family and society, and which is gradually perfected by conflict and survival of the fittest, it carries into settled life. But settled life entails multiplication into numerous such groups adjacent to one another; and in these changed circumstances each of the groups is sheltered from some of the actions which originated its organization and exposed to other actions which tend to disorganize it. Though there still arise quarrels among the multiplying families, yet, as their blood-relationship is now a familiar thought, which persists longer than it would have done had they wandered away from one another generation after generation, the check to antagonism is greater. Further, the worship of a common ancestor, in which they can now more readily join at settled intervals, acts as a restraint on their hatreds, and so holds them together. Again, the family is no longer liable to be separately attacked by enemies; but a number of the adjacent families are simultaneously invaded and simultaneously resist: coöperation among them is induced. Throughout subsequent stages of social growth this coöperation increases; and the families jointly exposed to like external forces tend to integrate. Already we have seen that by a kindred process such communities as tribes, as feudal lordships, as small kingdoms, become consolidated into larger communities; and that along with the consolidation caused by coöperation, primarily for offense and defense, and subsequently for other purposes, there goes a gradual obliteration of the divisions between them, and a substantial fusion. Here we recognize the like process as taking place with these smallest groups. Quite harmonizing with this general interpretation are the special interpretations which Sir Henry Maine gives of the decline of the *patria potestas* among the Romans. He points out how father and son had to perform their civil and military functions on a footing of equality wholly unlike their domestic footing; and how the consequent separate acquisition of authority, power, spoils, etc., by the son, gradually undermined the paternal despotism. Individuals of the family ceasing to work together exclusively in their unlike relations to one another, and coming to work together under like relations to state authority and to enemies, the public coöperation and subordination grew at the expense of the family coöperation and subordination. Not only militant activities, but also industrial activities in the large aggregates eventually formed, conduced to this result. In a recent work on "Bosnia and Herzegovina," Mr. Arthur J. Evans, describing the Slavonic house-

communities, which are dissolving under the stress of industrial competition, says, "The truth is, that the incentives to labor and economy are weakened by the sense of personal interest in their results being subdivided."

And now let us note the marvelous parallel between this change in the structure of the social organism and a change in the structure of the individual organism. We saw that definite nucleated cells are the components which, by aggregation, lay the foundations of the higher organisms; in the same way that the well-developed simple social groups are those out of which, by composition, the higher societies are eventually evolved. Here let me add that as, in the higher individual organisms, the aggregated cells which form the embryo, and for some time retain their separateness, gradually give place to structures in which the cell-form is greatly masked and almost lost, so in the social organism the family groups and compound family groups, which were the original components eventually lose their distinguishableness, and there arise structures formed of mingled individuals belonging to many different stocks.

A question of great interest, which has immediate bearings on policy, remains: "Is there any limit to this disintegration of the family?"

Already in the more advanced nations, that process which dissolved the larger family aggregates, dissipating the tribe and the gens and leaving only the family proper, has long been completed; and already there have taken place partial disintegrations of the family proper. Along with changes which for family responsibility substituted individual responsibility in respect of offenses, have gone changes which, in some degree, have absolved the family from responsibility for its members in other respects. When by poor-laws public provision was made for children whom their parents did not or could not adequately support, society in so far assumed family functions; as also when undertaking, in a measure, the charge of parents not supported by their children. Legislation has of late further relaxed family bonds by relieving parents from the care of their children's minds, and in place of education under parental direction establishing education under state direction; and where the appointed authorities have found it needful partially to clothe neglected children before they could be taught, and even to whip children by police agency for not going to school,[1] they have still further substituted for the responsibility of parents a national reponsibility. This recognition of the individual, even when a child, as the social unit, rather than the family, has indeed now gone so far that by many the paternal duty of the state is assumed as self-evident; and criminals are called "our failures."

Are these disintegrations of the family parts of a normal prog-

[1] *See Times*, February 28, 1877.

ress? Are we on our way to a condition like that reached by sundry communistic aggregates in America and elsewhere? In these, along with community of property, and along with something approaching to community of wives, there goes community in the care of offspring: the family is entirely disintegrated, and individuals are alone the units recognized. We have made sundry steps toward such an organization. Is the taking of those which remain only a matter of time?

To this question a distinct answer is furnished by those biological generalizations with which we set out. In Chapter II. were indicated the facts that, with advance toward the highest animal types, there goes increase of the period during which offspring are cared for by parents; that in the human race parental care, extending throughout infancy and childhood, becomes elaborate as well as prolonged; and that in the highest members of the highest races it continues into early manhood: providing numerous aids to material welfare, taking precautions for moral discipline, and employing complex agencies for intellectual culture. Moreover, we saw that, along with this lengthening and strengthening of the solicitude of parent for child, there grew up a reciprocal solicitude of child for parent. Among even the highest animals, of sub-human types, this aid and protection of parents by offspring is absolutely wanting. In the lower human races it is but feebly marked: aged fathers and mothers being here killed and there left to die of starvation; and it becomes gradually more marked as we advance to the highest civilized races. Are we in the course of further evolution to reverse all this? Have those parental and filial bonds, which have been growing closer and stronger during the latter stages of organic development, suddenly become untrustworthy? and is the social bond to be trusted in place of them? Are the intense feelings which have made the fulfillment of parental duties a source of high pleasure, to be now regarded as valueless? and is the sense of public duty to children at large to be cultivated by each man and woman as a sentiment better and more efficient than the parental instincts and sympathies? Possibly Father Noyes and his disciples, at Oneida Creek, will say Yes to each of these questions; but probably few others will join in the Yes—even of the many who are in consistency bound to join.

So far from expecting disintegration of the family to go further, we have reason to suspect that it has already gone too far. Probably the rhythm of change, conforming to the usual law, has carried us from the one extreme a long way toward the other extreme; and a return-movement is to be looked for. A suggestive parallel may be named. In early stages the only parental and filial kinship formally recognized was that of mother and child; after which, in the slow course of progress, was reached the doctrine of exclusive male kinship—the kinship of child to mother being ignored; after which there came in another long period the establishment of kinship to both.

Similarly, from a state in which family groups were alone recognized, and individuals ignored, we are moving toward an opposite state, in which ignoring of the family and recognition of the individual go to the extreme of making not only the mature individual the social unit, but also the immature individual; from which extreme we may expect a recoil toward that medium state in which has been finally lost the compound family group, while there is a reinstitution, and even further integration, of the family group proper, composed of parents and offspring.

And here we come in sight of a truth on which politicians and philanthropists would do well to ponder. The salvation of every society, as of every species, depends on the maintenance of an absolute opposition between the *régime* of the family and the *régime* of the state.

To survive, every species of creature must fulfill two conflicting requirements. During a certain period each member must receive benefits in proportion to its incapacity. After that period, it must receive benefits in proportion to its capacity. Observe the bird fostering its young, or the mammal rearing its litter, and you see that imperfection and inability are rewarded; and that, as ability increases, the aid given in food and warmth becomes less. Obviously this law, that the least worthy shall receive most, is essential as a law for the immature: the species would disappear in a generation did not parents conform to it. Now mark what is, contrariwise, the law for the mature. Here individuals gain rewards proportionate to their merits. The strong, the swift, the keen-sighted, the sagacious, profit by their respective superiorities—catch prey or escape enemies, as the case may be. The less capable thrive less, and on the average of cases rear fewer offspring. The least capable disappear by failure to get prey, or from inability to escape. And by this process is maintained that average quality of the species which enables it to survive in the struggle for existence with other species. There is thus, during mature life, an absolute reversal of the principle that ruled during immature life.

Already we have seen that a society stands to its citizens in the same relation as a species to its members; and the truth which we have just seen holds of the one holds of the other. The law for the undeveloped is that there shall be most aid where there is least merit. The helpless, useless infant, extremely *exigeant*, must from hour to hour be fed, kept warm, amused, exercised; as during childhood and boyhood the powers of self-preservation increase, the attentions required and given become less perpetual, but still need to be great; and only with approach to maturity, when some value and efficiency have been required, is this policy considerably qualified. But when the young man enters into the battle of life he is dealt with

after a contrary system. The general principle now is, that the benefits which come to him shall be proportioned to his merits. Though parental aid, not abruptly ending, may still sometimes soften the effects of this social law, yet the mitigation of them is but partial; and, apart from parental aid, this social law is but in a small degree traversed by private generosity. Then, when middle life has been reached, and parental aid has ceased, the stress of the struggle becomes greater, and the adjustment of payment to service more rigorous. Clearly with a society, as with a species, survival depends on conformity to both of these antagonist principles. Import into the family the law of the society, and let children from infancy upward have life-sustaining supplies proportioned to their life-sustaining labors, and the society disappears forthwith by death of all its young. Import into the society the law of the family, and let the life-sustaining supplies be inversely proportioned to the life-sustaining labors, and the society decays from the increase of its least worthy members, and disappearance of its most worthy members: it must fail to hold its own in the struggle with other societies, which allow play to the natural law that prosperity shall vary as efficiency.

Hence the necessity of maintaining this cardinal distinction between the ethics of the family and the ethics of the state—hence the fatal result if family disintegration goes so far that family policy and state policy become confused. Unqualified generosity must remain the principle of the family while offspring are passing through their earliest stages; and generosity, more and more qualified by justice, must remain its principle as offspring are approaching maturity. Conversely, the principle of the society must ever be, justice qualified by generosity in private actions, as far as the individual natures of citizens prompt; and unqualified justice in the corporate acts of the society to its members. However fitly in the battle of life among adults, the strict proportioning of rewards to merits may be tempered by private sympathy in favor of the inferior; nothing but evil can result if this strict proportioning is so interfered with by public arrangements that demerit profits at the expense of merit.

And now to sum up the several conclusions, connected though heterogeneous, to which our survey of the family has brought us.

That there are connections between polygyny and the militant type, and between monogamy and the industrial type, we found good evidence. Partly the relation between militancy and polygyny is entailed by the stealing of women in war; and partly it is entailed by the mortality of males and resulting surplus of females where war is constant. In societies advanced enough to have some industrial organization, the militant classes remain polygynous, while the industrial classes become generally monogamous; and an ordinary trait of the despotic ruler, evolved by habitual militancy, is the possession of numerous

wives. Further, we found that even in European history this relation, at first not manifest, is to be traced. Conversely, it was shown that with increase of industrialness and consequent approach to equality of the sexes in numbers, monogamy becomes more general, because extensive polygyny is rendered impracticable. We saw, too, that there is a congruity between that compulsory coöperation which is the organizing principle of the militant type of society, and that compulsory coöperation characterizing the polygynous household; while with the industrial type of society, organized on the principle of voluntary coöperation, there harmonizes that monogamic union which is an essential condition to voluntary domestic coöperation. Lastly, these relationships were clearly shown by the remarkable fact that, in different parts of the world, among different races, there are primitive societies in other respects unadvanced, which, exceptional in being peaceful and industrial, are also exceptional in being monogamic.

Passing to the consideration of the family under its social aspects, we examined certain current theories. These imply that in the beginning there were settled marital relations, which we have seen is not the fact; that there was at first descent in the male line, which the evidence disproves; that in the earliest groups there was definite subordination to a head, which is not a sustainable proposition. Further, the contained assumptions that originally there was an innate sentiment of filial obedience, giving a root for patriarchal authority, and that originally family connection afforded the only reason for political combination, are at variance with accounts given us of the uncivilized. Recognizing the fact that if we are fully to understand the higher forms of the family we must trace them up from those lowest forms accompanying the lowest social state, we saw how, in a small separated group of persons old and young, held together by some kinship, there was, under the circumstances of pastoral life, an establishing of male descent, an increasing of cohesion, of subordination, of coöperation, industrial and defensive; and that acquirement of structure became relatively easy because domestic government and social government became identical: the influences favoring each conspiring instead of conflicting. Hence the genesis of a simple society more developed than all preceding simple societies, and better fitted for the composition of higher societies.

Thus naturally originating under special conditions, the patriarchal group with its adapted ideas, sentiments, customs, arrangements, dividing in successive generations into sub-groups holding together in larger or smaller clusters according as the environment favored, carried its organization with it into the settled state; and the efficient coördination evolved within it favored efficient coördination of the larger societies formed by aggregation. Though, as we are shown by partially-civilized kingdoms existing in Africa, and by

extinct American kingdoms, primitive groups of less evolved structures and characterized by another type of family may form compound societies of considerable size and complexity, yet the patriarchal group with its higher family type is inductively proved to be that out of which the largest and most advanced societies arise.

Into communities produced by multiplication of it, the patriarchal group, carrying its supremacy of the eldest male, its system of inheritance, its laws of property, its joint worship of the common ancestor, its blood-feud, its complete subjection of women and children, long retains its individuality. But with these communities, as with communities otherwise constituted, combined action slowly leads to fusion; the lines of division become gradually less marked; and, at length, as Sir Henry Maine shows, societies which have the family for their unit of composition pass into societies which have the individual for their unit of composition.

This disintegration, first separating compound family groups into simpler ones, eventually affects the simplest: the members of the family proper more and more acquire individual claims and individual responsibilities. And the wave of change, conforming to the general law of rhythm, has among ourselves partially dissolved the relations of domestic life, and substituted for them the relations of social life. Not simply have the individual claims and responsibilities of young adults in each family come to be recognized by the state; but the state has, to a considerable degree, usurped the parental functions in respect of children, and, assuming their claims upon it, exercises coercion over them.

On looking back to the general laws of life, however, and observing the essential contrast between the principle of family life and the principle of social life, we conclude that this degree of family disintegration is in excess, and will hereafter be followed by partial reintegration.

THE TIDES.

By Professor ELIAS SCHNEIDER.

THERE has always been a difficulty in the minds of teachers, as well as in the minds of learners, to comprehend the theory of the tides as presented in our text-books. This theory fails to give a satisfactory account of the cause of the tides on the side of the earth most remote from the sun and the moon. According to this theory, at that part of the earth's surface which is turned away from the moon or from the sun, a less amount of attraction is felt by her waters than anywhere else on her surface; and the whole earth is therefore, in

effect, drawn away from the waters on the far side of her, and thus, the water being left behind, a tide is produced on this side, as well as on the side at which the force of gravity acts directly. That so great an absurdity could have been accepted so long by our writers of text-books, is truly marvelous. It is, indeed, so contrary to all known facts and laws of physics that, if no other influence were felt by the waters at the far side of the earth than attraction, there would be just the opposite effect produced to that alleged by this absurd hypothesis. This can be demonstrated by actual experiment, and as conclusively as any other fact coming within the reach of experimental philosophy. It has been proved experimentally that all bodies on the surface of the earth at midnight are heavier than at any other hour of the twenty-four; and that when new moon occurs at midnight, this increase of weight or gravity felt by matter on this part of the surface of the earth is still greater. Now, if this theory were correct, attraction would produce just the opposite effect; that is, matter would weigh less at midnight than at other hours of the twenty-four. On the side of the earth facing the sun and moon, the weight of bodies is diminished, as it should be, according to the theory which I propose to establish in this article.

The truth of this fact is very easily accounted for. Suppose the earth were placed in such a position, in space, that she could not feel *any* of the sun's attraction, nor that of any *other* body. Then gravity would be equal on all parts of the earth's surface, on the supposition of its being a perfect sphere and at rest. But now bring her within the attractive influence of the sun. Then all particles of matter on the earth's surface most remote from the sun would feel the force of gravity of both the sun and the earth; and these two forces would act in the same direction and in the same straight line, directed through the centre of the earth to the centre of the sun. On the side facing the sun, these two forces would also act in the same straight line, but in opposite directions. Hence a decrease of weight on one side and an increase thereof on the opposite side of the earth. The same result follows between the earth and moon under a similar supposition. It is therefore not true that the least amount of attraction is felt by the waters of the earth at that part of her surface most remote from the sun or from the moon. It is indeed true that the sun and moon *have* less power of attraction on the particles of matter at this part of the earth's surface than they have on particles of matter facing them. But, as attraction diminishes as the square of the distance increases, this attractive force of these two bodies on any part of the earth's surface is not near so great as that of the earth herself on such part of her surface. Therefore, as these remote particles feel the attraction of sun and moon *plus* the attraction of the earth herself, they are drawn with greater force toward the centre of the earth than any other particles. Consequently, it cannot be true that the whole

earth is drawn away from the waters, and that any tide is produced by the waters being left behind.

How, then, can we account for tides occurring on opposite sides of the earth at the same time? Let us see. In the first place, suppose the earth to occupy some place in space, and to be in a state of perfect rest. Then suppose the sun to come into position, and the earth to start on her journey of 68,000 miles an hour in her orbit around the sun; and suppose, too, that the earth rotates only once on her axis during one revolution around the sun. Then will the same side of her surface face the sun in every part of her orbit. Consequently, there will be a solar tide perpetually at a part of her surface, produced by centrifugal force, and at that part farthest from the sun. Night and solar tide will reign with unceasing steadiness at that one place; but there will be no motion of these piled-up waters. There they will stay, in a steady equilibrium, by the unceasing effect of centrifugal force, in the same manner as can be illustrated by swinging a hollow globe, partially filled with water, around the hand by means of a cord, or by swinging a bucket filled with the same liquid, and having for its bottom a piece of India-rubber, which bottom will bulge out when the bucket is swung around a centre, in the same manner as do the waters of the far side of the earth when she swings or sweeps around the central sun with a velocity of 68,000 miles an hour.

But there are always two solar tides occurring on opposite sides of the earth. The above explanation accounts only for the solar tide on the side of the earth farthest from the sun. How must we account for the fact that there is also one on her side facing the sun and occurring near noon? It is a well-known law of planetary motion that centrifugal and centripetal forces are precisely equal. By virtue of the first the earth seeks to fly from her centre of motion; by virtue of the second she has a tendency to fall into the central luminary; and everything on her surface is operated on in like manner. The particles of her water, moving very easily among one another, are therefore drawn readily away from her solid portions in opposite directions. On the one side the bulging out is caused by centrifugal, on the other by centripetal force. But, as these two forces are nearly equal in all parts of the earth's orbit, the tide-waves on opposite sides of her surface must also be nearly equal. The centrifugal force is produced by the revolution of the earth around the sun; the centripetal force is caused by the force of gravity lodged in the great central orb.

It must not be understood, however, that the earth in her orbital motion feels the effect of these two forces at her surface only. Every *particle* of the matter composing the earth feels both a centrifugal and a centripetal force while this planet moves around the central orb, and these two forces are precisely equal only at the *centre* of the earth. But the matter of her surface most remote from the sun feels

a centrifugal force that is in excess of the centripetal force felt at this same point; and the matter of her surface facing the sun, being nearest to it, feels a centripetal force that is in excess of the centrifugal force felt at this same point. But these two excesses are equal; hence there are equal solar tides at these points, while at the earth's centre there is an exact balancing of the two forces.

Suppose the matter of the earth were all condensed into the volume of a cubic inch, and that this small volume were placed at the earth's present centre; then suppose it received an impulse carrying it forward with a velocity equal to that which moves the centre of the earth, and that it were influenced by the sun, according to the law of gravity. This small volume, though equal in mass to the entire mass of the earth, would then move in the same curve in which the centre of the earth moves, and with the same velocity. But suppose this solid inch of matter were to be placed 4,000 miles farther from the sun, namely, at that point in space where the earth's surface is most remote from the sun. This solid inch, or whole mass of the earth, would then move in a longer curve than it would when at her present centre, as under the first supposition. But completing, nevertheless, in this longer curve, one revolution in the same time in which one revolution is completed in the shorter curve, at the earth's centre, the centrifugal force would be much increased; and, the centripetal force being also diminished in the same ratio, this cubic inch of matter would either abandon the sun's companionship entirely or make a *new* orbit of motion. In like manner are the waters of the earth operated on by centrifugal force at this point of the earth's surface. They have a tendency to fly off in a line tangent to the earth's orbit.

Now, suppose again that this condensed matter of the earth were placed at that point in space where the earth's surface is nearest the sun, namely, 4,000 miles nearer the sun than the centre of the earth is: then the whole mass of the earth's matter would move in a *shorter* curve than when placed at the centre, but, completing one revolution in no shorter period, the centrifugal force would be diminished; and, being also nearer to the sun, the centripetal force would be much increased by the central power of attraction. Therefore, this body of matter would, under this supposition, also leave its orbit, but it would be drawn *toward* the sun, and probably plunge into it. In the one case, the centrifugal being greater than the centripetal force, the body would fly *from* its centre of controlling power; in the other case, the centripetal being equally superior to the centrifugal force, the body would also be drawn out of its orbit, but dragged *to* the centre of controlling power. These suppositions are made to show, by way of illustration, the excessive force of each kind over its opposite, at opposite sides of the earth. And these equally excessive forces, acting in such opposite directions, cause the opposite solar tides. The particles of water, moving easily among one another, are

readily driven in opposite directions by these opposite forces. If the earth were *entirely* solid, then there could be no such bulging out of any of its matter, and therefore no tides.

A few words here in regard to the law of gravitation are in place. Every body of matter attracts every other body of matter, and with a force equal to the *amount* of matter each body contains; and this force diminishes as the square of the distance increases. Two bodies of equal mass approach each other equally; but, if one body contains four times as much matter as another, the smaller approaches the larger with a velocity four times as great as the larger does the smaller. Suppose two such bodies, being separated at a distance of 100,000 miles, attract each other with a certain known force: if this distance be increased to 200,000 miles, the force of attraction between these two bodies will be only one-fourth as great. In like manner, the earth, at the point farthest from the sun, feels a *smaller* degree of attraction than the matter at the centre. And, as the centrifugal force is also *greater* at this point than at the centre, there is here an excess of centrifugal over centripetal force, and sufficient, as can be ascertained by exact mathematical calculation, to produce a solar tide. And at that part of the earth's surface which is nearest the sun, or facing it, there is, according to the same law of gravity, an excess of centripetal over centrifugal force. Hence we have also a solar tide at this part of the surface of the earth.

I give one more illustration. Suppose the earth, at E (Fig. 1), is moving in a straight line toward E', and with a velocity of 68,000 miles an hour; and suppose when she reaches E' she comes under the

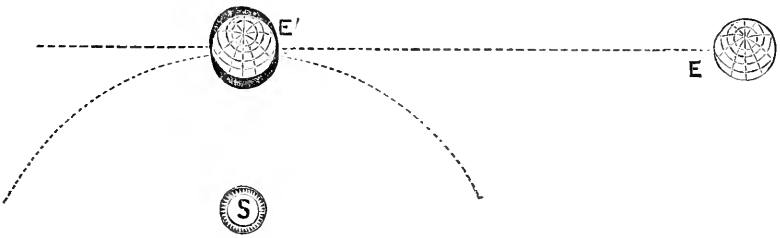

FIG. 1.

attractive influence of the sun. She will then be deflected from her rectilineal course and move in a curvilineal orbit around the sun. That part of her surface turned away from the sun will be 8,000 miles farther from the attractive influence of the central orb than that part of her surface facing the sun. Hence this remote part will have a greater tendency to continue moving on in a straight line than any other part; and this tendency will show itself in the motion of its waters, by producing a tide. The waters will have a tendency to move in a line tangent to the orbit of the earth. The part of the

earth's surface nearest the sun, being acted upon more powerfully by the gravitating influence of this central force than the remote part, will show a less tendency to move on in a line tangent to the earth's orbit. Hence there will be another tide produced by gravity directly.

I have thus far spoken only of the solar tides. It will be necessary also to say something of lunar tides, or what influence the moon has on the phenomena of the tides.

It is a well-known fact that there is a point between the earth and her moon called their centre of gravity. The distance between the centres of these two bodies is about 240,000 miles. A rough calculation brings the centre of gravity of these bodies about 2,687 miles from the centre of the earth, and 237,313 miles from the centre of the moon. This point describes the curve of an ellipse around the sun; and the earth and moon revolve *around* this point, while they both sweep through space in their majestic journey around the sun. It is therefore evident that the earth, in her ceaseless motions, is influenced by three different centrifugal forces. The one is produced by rotation on her axis; the other by her revolution around the sun; and the third by her revolution around the centre of gravity between herself and the moon.

Let us suppose that the earth and moon have no other motion in space than that of revolving around their common centre of gravity, and that the same side of the earth is always facing the moon. The earth will then feel a centrifugal force on her side farthest from the moon, and equal to the centripetal force felt on her side facing the moon. These two equal forces, acting in opposite directions, will cause tide-waves on opposite sides of the earth; and they will be produced in the same manner as the opposite ones, spoken of already, are produced by centrifugal and centripetal forces felt by the earth in her orbital motion around the sun.

Let us now place the earth and moon in their proper position with respect to the sun; and let us suppose the moon to be in conjunction with the sun, as at *A*, Fig. 2. It is then new moon, and the moon's centre is 237,313 miles *within* and the earth's centre 2,687 miles *outside* the elliptic orb described by their centre of gravity. At this point of her path the earth feels, therefore, the greatest amount of centrifugal force on the side of her surface farthest from the sun. This large amount of centrifugal force is produced by axial rotation, by revolution around the sun, and by revolution around the centre of gravity already named. The direction of these three forces is in the same line. The motion of this part of her surface, which is in this line of direction, is therefore the most rapid; consequently, the centrifugal force felt here is also the greatest. *Therefore*, we have one of the highest tides when the moon is in conjunction with the sun; and, since centripetal is always equal to centrifugal force, the side of the

earth facing the sun and moon at this point of her orbit must have an equally high tide at this time. The centripetal force here is produced by the gravity of both sun and moon acting jointly.

Let us now suppose the moon to be in quadrature, as at *B*. Then the two centrifugal forces, the one produced by revolution around the sun, the other by revolution around the centre of gravity of these two

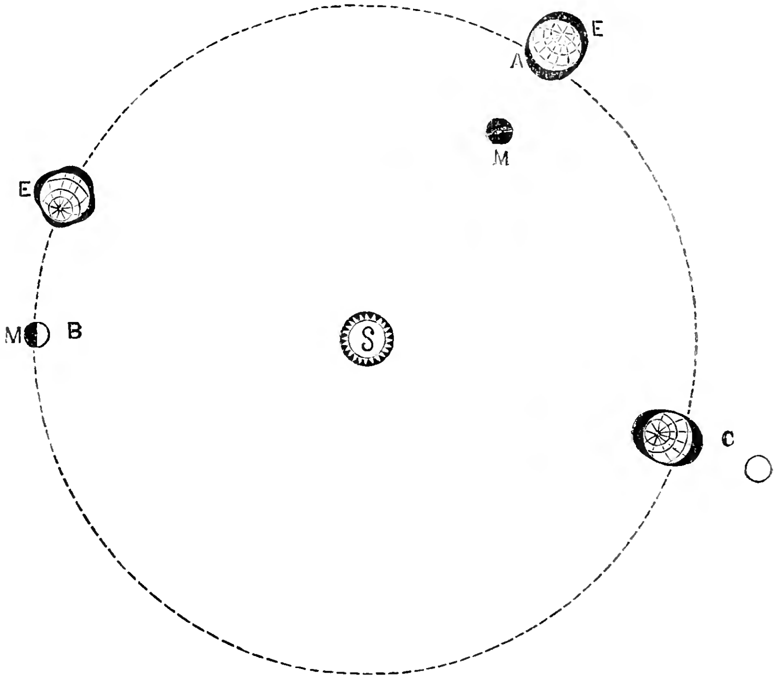

Fig. 2.

bodies, do not act in the same line of direction, but at right angles with each other. The phenomena of solar and lunar tides are then about 90° apart; the solar being the smaller and the lunar the larger. Here the centres of both earth and moon are *in* the path described by their centre of gravity.

In the last place, let us suppose the moon and sun to be in opposition, as at *C*. Then, according to my theory, the earth feels, on her side farthest from the sun, an influence which diminishes the centrifugal force produced by her orbital revolution. For at this point the earth's centre is *within* and the moon's centre is *without* the elliptic path described by their centre of gravity. Here the revolution of the earth around this centre of gravity is contrary to her general motion around the sun. But what is thus lost in centrifugal force on her side turned away from the sun is more than made up by the

gravity exerted directly on her by the moon. And, on the side of the earth facing the sun, she feels a centrifugal force produced by revolution around the centre of gravity of herself and the moon, and also a centripetal force produced by the gravitating influence of the sun. Hence there must be high tide also when sun and moon are in opposition.

It is a known fact that the solar are less than the lunar tides. How must we account for this fact? The sun is a body so large that the mass of the moon is not much more than a grain of sand in comparison with it. But it must also be remembered that gravity diminishes as the square of the distance increases; and as the moon is very near the earth, and the sun a great way off, the lunar influence is much more strongly felt in the phenomena of tides than the solar influence.

The amount of centrifugal force felt by a body moving in space around a centre depends, not only on the velocity with which it moves, but also upon the *size* of the curve in which it moves. If the circumference of the curve is very large, it differs not much from a straight line. If a body moves in space in the direction of a straight line, it feels no centrifugal force at all. If it is deflected from the direction of this straight line, only a very little, the circumference of the curve will be very long, and the centrifugal force will be small. But, if it is very much deflected, the curve becomes very small, and the body, turning around very "short corners," has a strong tendency to fly "off the track." In other words, in a short curve the centrifugal force is very great.

Now, let us make an examination of the orbital curve of the earth made in its motion around the sun. The length of the circumference of this curve is, in round numbers, about 570,000,000 miles. A straight line, 10,000 miles in length, tangent to this curve at one end, is only about .526 of a mile distant from the circumference at its other end. Therefore, the earth, moving in this orbital curve, feels rather a small amount of centrifugal force. But, in her motion around the centre of gravity between herself and the moon, she turns very "short corners," and hence under this influence she experiences a greater amount of centrifugal force than in her motion around the sun. For this reason, *also*, the lunar are greater than the solar tides.

If the earth had only one rotation in one revolution around the sun, there would be, as already stated, one solar tide by virtue of centrifugal force occurring at midnight, and another by virtue of centripetal force occurring at noon. That is, perpetual night and high tide would occur at one side, and perpetual day and high tide at precisely the opposite side of the earth. But now let us suppose the earth rotates on her axis once every twenty-four hours, and from west to east, as she actually does rotate: then there will be motion of the waters; but this motion will be only *apparent* motion, and from east to west.

The *real* motion will be that of the solid portion of the earth that moves from west to east, and underneath these waves, though these waves do also acquire, by means of friction, a *part* of this motion; yet the centrifugal and centripetal forces are so much superior as to master the effect of this friction. This frictional force carries also these tide-waves so far eastward that they occur always several hours east of the meridian; that is, several hours *after* noon, and several hours after midnight.

It is a known fact that the waters of the tides rush up the rivers and small bays on the east coasts of all countries with great violence, but not up those on the west coasts. The reason of this is very evident. The west coasts turn away from the tide-waves; while the east coasts, moving with a velocity of nearly 1,000 miles an hour, in rotation, within all parts of the tropics, dash violently eastward against these waves. For this reason the waters, by resistance or inertia, *appear* to be driven violently westward up the streams and bays, while it is the mouths of these channels ploughing with violence into the tide-waves themselves.

It has been stated in this article that gravity is greater at that part of the earth's surface turned away from sun and moon than anywhere else. It may be asked, "How then can centrifugal force drive out the water above the usual level when its weight is increased?" This force acts in a line tangent to the earth's orbit, which tangent line, being perpendicular to the radius vector at perihelion and aphelion, and at all other points in the earth's orbit very nearly so, may be said to be at right angles with a line extending from this point of tangency through the centre of the earth to the centre of the sun. Therefore, the attractive power of the sun acts on matter, at the part of the earth most remote from it, in the direction of the radius vector; and centrifugal force acts on this same matter in a direction at right angles with the radius vector. Now, as was first demonstrated by Galileo, the motion of a body, produced by one force, is not destroyed by another force acting on this same body at right angles with it. The result of these two combined forces is only a change in the *direction* of motion. But, as has already been shown, centrifugal is always in excess of centripetal force at the place of the earth now under consideration. Hence this tide-wave at this side.

I conclude by saying that the great motions of the waters of the mighty deep are most assuredly the grandest ocular demonstrations of the rotation of the earth upon her axis, and of her revolution around the sun, that can be witnessed by the eyes of man.

ON GROUND-AIR IN ITS HYGIENIC RELATIONS.[1]

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IF in the two preceding lectures I have tried to draw your attention to the penetration of the air into our clothing and our dwellings, I shall try in this last lecture to do the same in reference to the air which is in the ground, and to its connection and intercourse with the air above the ground. The air in the ground has been somewhat a stranger to our minds; the terms air and earth, just like air and water, implied to our mind things contrary, and exclusive of each other. The earth seemed to have its limit where the air began. Common-sense seems inclined to believe that there can be no air in that whereon we walk and stand. If we say of the surface of the earth that it is the limit of the earth and the beginning of the atmosphere, we are not correct in reference to the latter. The air begins much below the ground, and we ought to say that where the ground, which is a mixture of earth, water, and air, ends, from there the atmosphere exists alone. It is no wonder that no particular attention was paid to the air in the soil; its presence there does not make any direct impression on any one of our senses; we infer its presence more from other experiences and consequent conclusions. The human mind formerly looked upon the air as something unsubstantial, spiritual, although men saw the effect of hurricanes; no wonder, then, that no one thought of the air hidden in the ground, which cannot even blow the hat from our head.

We again meet here with the fact that, originally, only that calls forth ideas which impresses our senses directly. No one doubts that water penetrates the soil, and moves there according to hydrostatic laws, because we see it run, vanish into the soil, collect and run out again, or we pump it up; but hitherto not many have clearly understood that the whole surface of the earth, as far as it is porous and its pores are not filled with water, contains air, which is also subject to aërostatic laws. And why so? One feels nothing of that air; it is always calm, it has no color, no smell, no taste, in fact we take it for nothing. I have shown you already how great an error we commit when we suppose a calm air to be motionless. This applies just as much to the air in the soil, which, if its motion were even snail-like, would still travel from a good depth to the surface in one day.

Perhaps I shall succeed in giving you a better idea of the change of the air in the ground than of that in walls. To have a correct idea

[1] Abridged and translated by Augustus Hess, M. D., member of the Royal College of Physicians, London.

of that air and its relations, we must know, in the first instance, its quantity in proportion to the different kinds of soil. Let us first take rubble-soil, gravel, or sand, which support the largest and heaviest edifices. Here is a bottle which holds exactly one litre ($1\frac{7}{10}$ pint) up to that mark on its neck. I have filled it slowly with gravel, shaking it all the while, so that the gravel settled completely. The gravel reaches up to the mark. This high cylinder contains just one litre of water, and is graduated into one hundred parts. Now I pour the water into the gravel, till I find it just coming up to its surface, and I see that of the water in the cylinder thirty-five parts have entered the gravel and driven out the air, which before had therefore taken up thirty-five per cent. of the whole mass. This is certainly a great quantity of air, and if we build a house on such a ground its weight rests, no doubt, on the gravel alone, and not on the air; but for all that, this ground, as far as it is dry, consists to the extent of one-third of air. In building on gravel, we build as well on air, just as we build on water when we build on piles driven into a swampy soil and cut off under the water. We know well that a house standing on piles stands with its foot in water, that this water is drawn up by the walls till beyond the water-mark, that the water of the ground has a good deal to do with the house; why should we, then, refuse to acknowledge that the foot of a house built on dry gravel, stands also on the air, and that the air in the ground is in intimate relation with the house?

What I have shown you in regard to gravel, can, in a similar way, be proved in regard to sand, clay, and even more solid stony and rocky soils.

Most kinds of sandstone are nearly as porous as loose sand. The rock of Malta has been proved by Leath Adams to suck up water on an average to one-third of its volume; consequently, when dry it must contain air to the same extent. One would not think that this was the case with the rugged cliffs and shores of that remarkable island, which look as if they were built up from the granite of the Swiss Alps. Most buildings in Malta are built with this Maltese rock, which is much used also throughout Italy. It is not less porous than the Berlin sands; their penetrability for air and water is the same, but the grains of the Maltese rock are connected by some solid medium, while the grains of the sand are loose. In respect to their porosity they stand relatively as frozen and not frozen soil.

Many ships of the English navy have filters made of a certain kind of Maltese rock. I have tested one, and I have found that the filtering basin swallows up forty-seven per cent. of its whole contents, when used for the first time.

A soil whose pores are filled partly by air and partly by water is called damp. It can take up more water till all its pores are filled with it, when all passage of air is stopped, just as we have seen

with regard to the mortar of the house. That degree of humidity of the soil is called *ground-water*; it begins at the lowest limit of the air in the soil.

It is well known that water becomes solid at a temperature below freezing-point. In becoming ice it changes its consistency totally, but its volume not very much, increasing it by about six per cent., one hundred volumes of water becoming one hundred and six of ice. In a frozen soil there must have been a certain quantity of water. This water in freezing has become a kind of cement for the particles of the soil, and gives it a solidity which the liquid water could not

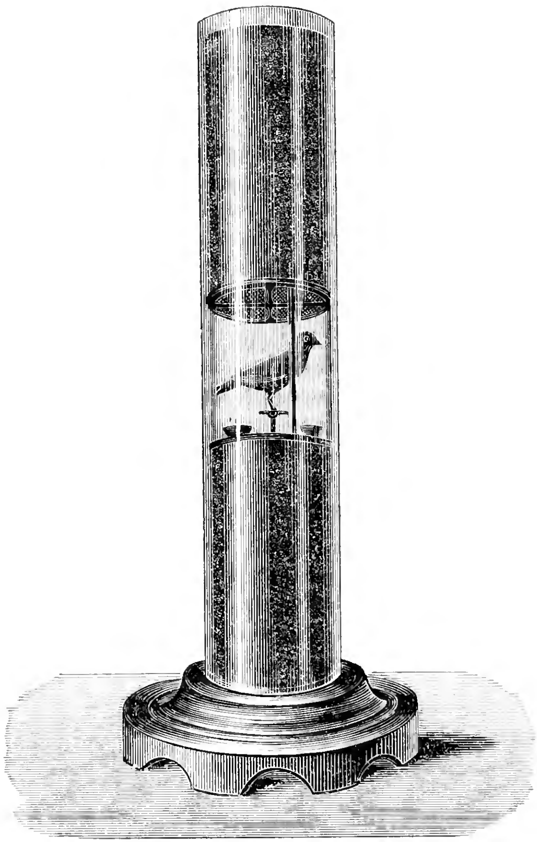

FIG. 1.

impart. Although such frozen soil is as hard to work as stone, we have no right to assume that it is impermeable to air or gases of any kind.

Those pores of the soil which were free from water cannot be narrowed much by the expansion of the neighboring pores through the

freezing of their water. It would be just as incorrect to deny the permeability to air of the frozen soil as that of the Maltese rock. Still, the most erroneous views have been formed on this subject, even by men distinguished in other branches of science.

Having given you an idea of the quantity of air in a porous soil, I have to give you a correct idea of the mobility of this air and of its change, and I shall try to do this in a roundabout way, as I cannot do it by direct impression on your senses.

There are things of whose existence we become only aware when they are absent. Probably the fish is as little aware of the water he lives in as we of the air, till he finds himself on the dry land. The creatures living in the air know nothing of its oxygen, but, when we place them in an atmosphere which has none or too little of it, or too much carbonic acid, they will feel and behave like the fish out of water. There is a difference in the want of oxygen between different animals; birds want a good deal proportionately. A canary-bird takes about one and a third cubic inch of oxygen from the air in one hour. In one litre of air there are about thirteen cubic inches of oxygen, which the bird would have consumed in ten hours. But he would be dead long before, as he could not live in an air deprived of one-half of its oxygen. The bird in this glass cylinder has been shut up between gravel for the last ten hours, and you see he is quite well. The cylinder is shut at its lower end by a wire netting, on which a stratum of gravel rests. The bird stands on the gravel, and above him there is another wire netting, which supports a stratum of gravel. The free space for the bird contains about one litre of air.

This bird is shut up in the same way as workmen sometimes are, digging at a well or at some kind of shaft. If accident does not kill them at once, they seldom die from want of air, even if it takes some days to dig them out, although man's consumption of oxygen is about a thousand times as great as that of the canary-bird. Some years ago, in Saxony, two men who were shut up in the shaft of a well for ten days kept alive, and were not much the worse for it when they came out again. I may mention here that the celebrated Fraunhofer, when still apprenticed to a glazier at Munich, was buried for several days under the ruins of his master's house, which had fallen in.

I expect Fraunhofer's luck will be shared by this bird, whom I intend removing to-morrow to his old cage.

You cannot longer have any doubt about the motion of the air through gravel: but I want to convince your senses; I want you to *see* the motion of the air, and to *see* that motion taking place through a much thicker stratum of gravel than the strata shutting in the bird.

You see this high glass cylinder (Fig. 2), with a smaller glass tube inside, open at both ends. The cylinder is filled with gravel, and the glass tube connected with a manometer by some India-rubber tubing.

As soon as I blow gently on the upper surface of the gravel, you see the liquid in the manometer moving. The motion of the air which I produce acts in the first instance on the surface of the gravel, propagates itself through the same to the bottom of the cylinder, enters

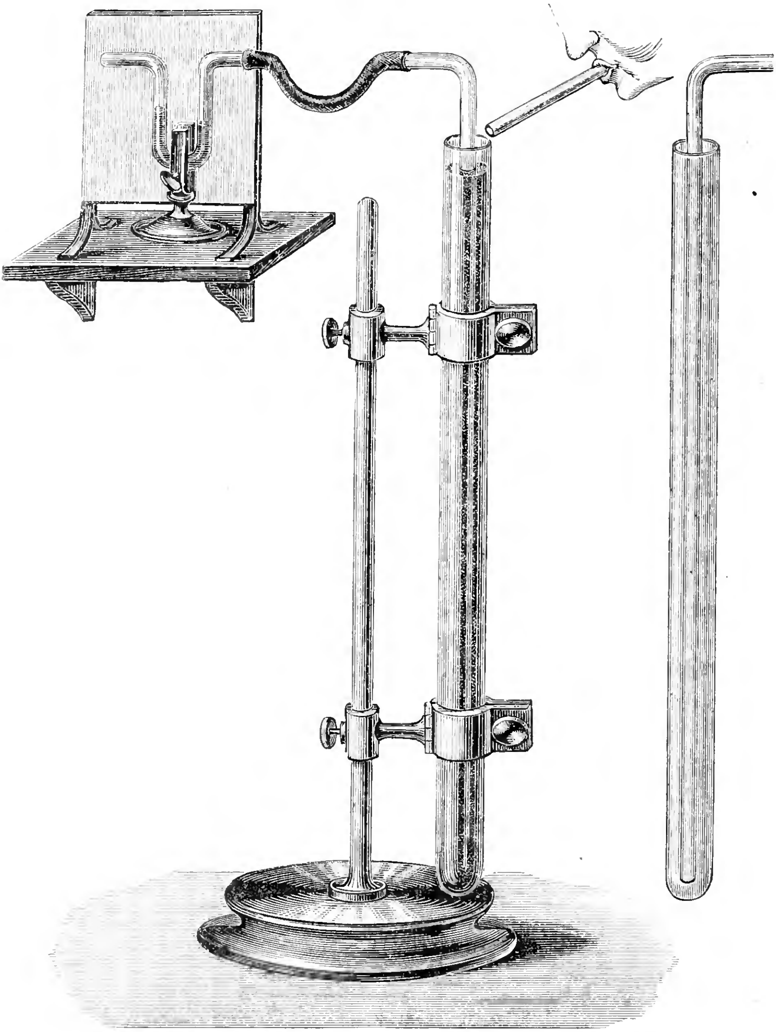

Fig. 2.

the lower end of the tube, rises through it and through the tubing into the manometer, where it presses on the column of liquid, and sets it in motion.

Why does the liquid move in the manometer? Because the air, after the migration just described, presses with greater weight on the

surface of the column it arrives at than the outer air on the surface of the other column. If there were no liquid in the manometer, the moved air would finally flow out of the manometer, and, as you see, now that I have emptied the manometer, nearly blow out this candle.

In this way I believe that I have convinced your senses that the air can move through porous soils.

If the air in the ground can be set in motion by the pressure of air or wind against its surface, there can be no doubt that the same can be effected by differences of temperature, and by diffusion, and generally by all causes which can produce movement of gases. As long as the air in the ground is of a different temperature or composition from the free atmosphere, there must be exchange and motion. I will only, in order to leave no doubt on your mind, direct your attention to several well-known facts, which can only be explained by the change of the ground-air.

All Christian nations bury their dead in the earth, to give back to dust what came from dust. There are burial-grounds in which a corpse decays completely in six to seven years, and others in which it takes twenty-five to thirty years. The regulations about a second occupation of a ground depend on this difference, and therefore towns with an equal population may be obliged to have burial-grounds of very different sizes. There are other circumstances of some influence on the process of decay, but the principal one is the amount of, and the facility for, the change of the air in the soil. Rubble and sandy soils do the work much quicker than marl and clay soils. Striking experiences in this respect have been made on the French battle-fields, chiefly near Sedan, where a Belgian chemist, Louis Creteur, had to disinfect the large dead-pits. The bodies were buried in chalk, quarry, rubble, sand, argillite, slate, marl, or clay soils, and the sad work lasted from the beginning of March to the end of June. In rubble the decay had taken place fully, but in clay the bodies were surprisingly well kept, even after a very long time, and even the features could be identified.

As the processes of putrefaction and decay are intimately connected with the activity of certain lower organisms, which prey upon the dead, it is sufficiently clear that these organisms must thrive differently in different kinds of soil. A lively change of air and water in the ground appears to be of great influence in this respect; the more air in the ground the richer the underground life.

Remarkable testimony as to the permeability of the ground, and of the foundations of our houses, has been given by gas emanations into houses which had no gas laid on. I know cases where persons were poisoned and killed by gas which had to travel for twenty feet under the street, and then through the foundations, cellar-vaults, and flooring of the ground-floor rooms. As these kinds of accidents happened only in winter, they have been brought forward as a proof that

the frozen soil did not allow the gas to escape straight upward, but drove it into the house. I have told you already why I take the frozen soil to be not more air-tight than when not frozen. In such cases the penetration of gas into the houses is facilitated by the current in the ground-air caused by the house. The house, being warmer inside than the external air, acts like a heated chimney on its surroundings, and chiefly on the ground upon which it stands, and the air therein, which we will call the ground-air. The warm air in the chimney is pressed into and up the chimney by the cold air surrounding the same. The chimney cannot act without heat, and the heat is only the means of disturbing the equilibrium of the columns of air inside and outside the chimney. The warm air inside is lighter than the cold air outside; and this being so, the former must float upward through the chimney, just like oil in water. It continues to do so as long as fresh cold air comes into its neighborhood from outside. As soon as we interrupt this arrival, the draught into the chimney is at an end. Any other way of looking at the action of chimneys leads to erroneous views, which have many times stopped the progress of the art of heating and ventilating.

Thus our heated houses ventilate themselves not only through the walls but also through the ground on which the house stands. If there is any gas or other smelling substance in the surrounding ground-air, they will enter the current of this ventilation. I have witnessed a case in Munich, where not the least smell of gas could be detected in the street, but a great quantity of gas found its way into the ground-floor room of a house where no gas was laid on. In another case the gas always penetrated into the best heated room and produced an illness of its inmates, which was taken for typhoid fever.

The movement of gas through the ground into the house may give us warning that the ground-air is in continual intercourse with our houses, and may become the introducer of many kinds of lodgers. These lodgers may either be found out, or cause injury at once, like gas; or they may, without betraying their presence in any way, become enemies, or associate themselves with other injurious elements, and increase their activity. The evil resulting therefrom continues till the store of these creatures of the ground-air is consumed. Our senses may remain unaware of noxious things, which we take in, in one shape or another, through air, water, or food.

We took rather a short-sighted view all the while, when we believed that the nuisances of our neighbors could only poison the water in our pumps; they can also poison the ground-air for us, and I see more danger in this, as air is more universally present, and more movable, than water. I should feel quite satisfied if, by my lectures, you were convinced of this important fact, if of none other.

England has given proof how the public health can be improved,

by keeping the soil clean through good drainage, abolition of cess-pools, and abundant water-supply. It would carry me too far if I were to analyze now to which of these measures the lion's part belongs; I should have to enter upon many controversies, which I have no time to fight out in this place; but this is my conviction, which I want to impress upon you, that cleanliness of the soil and diminution of organic processes in the ground of dwelling-houses are most essential.

Many have considered these processes, and their effects on the ground-air, to be a mere hypothesis. This view lies now behind us, and facts have been found proving their reality. Stimulated by the investigations of Huxley and Haeckel, further researches have followed, and shown that not only at the greatest depth of the sea, but also in every porous soil, there are everywhere those beginnings of organic life, belonging neither to the animal nor vegetable kingdom, mucous formations, which are called Moneras and Protistes. When I wrote my part of the report on the cholera in Bavaria, in 1854, I pointed out already that the air, not less than the water in the soil, ought to be drawn into the circle of experimental investigations. Neither others nor myself acted at once upon my suggestion, and it is only during the last eighteen months that I have examined the ground-air in the rubble-soil of Munich, regularly twice a week, for its varying amount of carbonic acid. The results are surprising, and for the future I shall have to trouble others and myself, not only with ground-water, but also with ground-air.

The place where the examination of the ground-air of Munich is being carried on is rubble, without any vegetation, and the carbonic acid increases with the distance from the surface. Agricultural chemistry has been aware, for a long time, that a clod of arable earth which is rich in humus is a source of carbonic acid, but no one expected that, at times, so much carbonic acid should be met with in sterile lime-rubble. A few feet under the surface there is already as much carbonic acid as in the worst ventilated human dwelling-places.

I have found that the quantity of carbonic acid is smaller at fifty-eight inches than at one hundred and fifty-six inches throughout the year, the months of June and July excepted, when an inverse proportion arises. But then there begins also, in the lower stratum, a considerable increase, so that the upper stratum soon finds itself behind again. This large quantity of carbonic acid in the ground-air of Munich has been far surpassed in Dresden. Examinations have taken place in that town under the authority of the Central Board of Public Health. Prof. Fleck's diary proves that, at least at that spot where his examinations took place, the quantity of carbonic acid was in winter already nearly twice as great as in Munich in the month of August. I might become jealous of Dresden, but we must often,

in life, put up with being left behind, although we had the first start, and I have no choice left but to resign myself.

The presence of carbonic acid in the soil and its periodical motion are for the present a bare fact. Other places, with different soils, must be examined under varying circumstances, and for longer periods, before an explanation can be attempted.

The first question which naturally meets us is that about the origin of this gas. It cannot spring from the humus of the surface, because at Munich and Dresden its quantity is smallest in the immediate neighborhood of the surface, where the humus lies, and increases in proportion to the distance thence. As the amount of carbonic acid in the ground-air generally increases the nearer this is to the ground-water, we should be at first sight inclined to assume that it evaporates from it. Is it not a fact that the ground-water which feeds wells and sources contains this gas? And is it not well known that many a well's shaft contains so much carbonic acid as to extinguish a burning candle at the distance of a few feet only from its opening? This assumption, however, is not justified for several reasons, according to the researches and experiments made at Munich: 1. There are two months in the year when the amount contained in the upper stratum, which is at the greatest distance from the ground-water, is larger than in the lower. 2. I have examined simultaneously, at given places, the amount of the gas both in the ground-water and in the ground-air, and have investigated whether, according to the laws of diffusion and absorption, either had a surplus of the gas, and was accordingly in a condition to receive or yield some of it. In every case the amount of carbonic acid in the ground-air was larger by fifty per cent. than in the ground-water, so it is clear that it is the water which receives its carbonic acid from the air, and not *vice versa*.

Hereby the question about the origin of the gas is certainly not yet answered, and would have been left equally unsettled if we had to ask, Whence comes all the carbonic acid which is found in the ground-water? All this water is precipitated from the atmosphere, from rain or snow. In entering the soil as meteoric water its amount of carbonic acid is exceedingly small. By help of Bunsen's analytical tables it is easy to calculate, from the quantity of carbonic acid in the atmosphere, and the absorbing power of water for this gas, that one pint of rain-water at the average temperature and barometrical pressure can only contain a very small fraction of a grain of carbonic acid, and this has been proved further by analytical experience. But the analysis of the pump-water in Munich which was poorest in carbonic acid showed that it contained on an average $1\frac{1}{2}$ to $1\frac{9}{10}$ grain of the free gas. The ground-water at the places of examination stands about sixteen feet from the surface. It is therefore evident that the meteoric water, which is the sole source of the ground-water, must more than centuple

its original amount of carbonic acid before it reaches the wells. Thus much is certain, that the source of the carbonic acid must be sought for in the soil, and for this reason the more natural supposition is, that the soil yields the gas and gives it to the water and to the air simultaneously, but naturally with greater facility and in greater quantity to the air than to the water. The sources of the carbonic acid in the soil have now to undergo a stricter investigation; the probability is, they owe their origin to organic processes in the soil.

Allow me, now, a few more concluding and valedictory words.

In the introduction to my lectures I thought it incumbent upon me to give you my views about popular lectures in general. Those views necessarily excluded the possibility of disposing, in a few hours, of any one subject of hygiene in such a manner as to impart to my audience a thorough theoretical and practical knowledge. My hesitation in selection lasted some time. I might have collected and described the last works and tendencies in the field of hygiene, pointing out what had practically succeeded, and what ought to be aimed at further—and there is a series of interesting points and facts, forming a most grateful subject for lecturing; or I might have attempted to give you a survey, a kind of bird's-eye view of the whole domain of hygienic science. There is a charm, in the contemplation of a grand and beautiful distant landscape, in marking, first, the more interesting points; then to let the eye wander round them till it comes to the next striking point, and to enjoy to the utmost the sight of the rich view.

I might, perhaps, have succeeded in satisfying your expectations up to a certain point, but I thought it preferable to direct and to concentrate your attention mainly upon one single object which is known to every one, and which seems to be so thoroughly examined that many believe that there is very little to say about it—the air, in its hygienic relations to man's clothing, to his dwelling-place, and to the soil on which he builds.

It is such a natural error to imagine that we cannot but understand everything with which we are in continual intercourse; but, if we take the trouble of looking a little more closely into everything of which we make daily use, we shall soon make the humiliating discovery that we are acting preëminently according to instinct and tradition, and much less by personal understanding. Each period has its own task, to contribute and to create something by which civilization gains materially or ideally. But if at any one period we examine into the daily life of its generation, we shall find a great deal more that is inherited than self-acquired. This fact ought to make us modest and zealous, but also just and thankful toward our forefathers, who did not possess or know many things which we possess and know now.

As animals make use of Nature and her laws in a multifarious and surprisingly appropriate manner, so does man also. Each carrier on the road makes use of the laws of motion and friction, and of those

of living force and its preservation, but he does so for the most part quite mechanically, so that he appears to think no more about it than the beaver when he builds his hut. Man also does most things long before he understands them, and this is part of his nature. If he could make use of things only after having thoroughly investigated them, his life would be a poor one, and barely possible. If we had to study the functions of our clothing and its material before we could put it on, we should be frozen to death long before, and no carrier would have attempted to horse his cart before the time of Galileo and Newton.

Here I find myself drawing a dangerous parallel. You may ask me at once whether I believe a carrier will be a better carrier for understanding the laws of motion, and whether our clothing and our dwellings will one day be superior to what they are now, because we shall then have learned to understand their functions better. I leave the answer to the future with the utmost confidence. The experience of the past sets me completely at ease. At all times and everywhere it has been the case that each progress in the recognition of laws, that each new fact established, and each new method applied by science, each new way on which science has directed us, has finally had its practical and useful consequences. Excuse me if I continue to dwell on this favorite subject of mine.

What men call useful is quite a relative term; they call a thing so as soon as they find out what use they can make of it. Of course, a thing must exist before we recognize it, and we must become aware of certain of its properties and relations before we can make use of them for any practical purpose. Certainly the recognition of the laws of motion by Galileo, Kepler, Newton, Laplace, and others, has not brought about a revolution, or made a sensation among the carriers, but from these recognized laws sprang and were evolved new ideas, purified from the gross primitive slag, and they led on to the railway, etc. Other examples demonstrate still more clearly the connection between theory and practice.

Electric telegraphy, which is not only practical and useful, but already indispensable to us, had its first origin in the observations of the anatomist Galvani, who saw the legs of frogs quiver when they came in contact with different metals. Imagine to yourself great practical men of the time, whether statesmen, or divines, or soldiers, or physicians, witnessing Galvani's experiments going on year after year; certainly every one of them would have thought that the man could apply himself to something more useful. But from that form of electricity which Galvani detected there sprung the researches and works of Volta, Sömmering, Steinheil, Morse, and Wheatstone, to whom we owe the whole of our telegraphic system. Place together in your mind the quivering leg of the frog and the transatlantic cable.

After the discovery of Columbus the Spaniards found in the sand

of a river grains of a white metal, which was not affected by fire, and appeared, therefore, to be a noble metal. Quantities were brought to Europe, and the new metal received the modest name of *platina* (low silver), this being a diminutive of *la plata* (silver). The masters of the Mint, the gold and silver smiths, had soon formed their ideas about the new metal; it could neither be melted by itself, nor hammered, nor rolled, nor dissolved in *aqua-fortis*. It was only soluble in *aqua-regia* and other melted metals, but the combinations were all brittle and discolored; in short, it came to be considered a perfectly useless metal, practically worth less than lead and iron. Its importation was prohibited by the Spanish Government, because there was danger of its high specific gravity leading to its use for the adulteration of gold. What platina there was in the country already was thrown into the sea by order. But Science, who makes no difference between the useful and useless, and considers everything useful which increases our insight into the things that are, has quietly held intercourse with the outcast metal; she learned how to tame the shrew, and since Wollaston platina is considered to be one of the most pliable and useful of metals; just what were originally considered its vices have enhanced its value so much in the course of time that weight for weight the "low silver" is paid seven times as much for as the "high silver."

Modern times have not ceased furnishing numerous examples of the same kind, showing that it is not the business of science to ask for the immediate profit, for the immediate practical use. They do not fail to come forth in time.

Science may point to the words of the Bible: "But seek ye first the kingdom of God and his righteousness, and all these things shall be added unto you." All sciences are provinces of God's infinite kingdom, and in them, as everywhere in God's kingdom, Justice is dealt by Truth alone. This was my standpoint, which helped me over the doubts I might have had concerning the *utility* of these lectures. It seemed to me that the principal thing was not to present to you a series of practical applications and contrivances, but a series of truths, which carry in themselves their use and applicability, and impose their authority in proportion as they are talked over more frequently, understood more clearly, and felt more vividly.

But I wanted to tell you the whole truth about the things which formed the subject of my lectures, and it became my duty to draw your attention not only to what is positively known, what is complete, what requires no further investigation, but also to point out to you much greater fields of hygiene, where scarcely a seed has been sown. Otherwise I should probably have jeopardized the only and immediate practical use which my lectures can have here, and which I believe to be this: that the conviction may spread and take root everywhere, that hygiene has been neglected until now, prac-

tically as well as theoretically, and that this neglect is a dark spot on our civilization, which has to be removed by this generation This conviction begins just now to lay hold of ever-widening circles of society, and a certain sympathy is stirring for the interests of public health, much more than formerly. The weather seems suitable for ploughing fields which have remained untouched, and for sowing good seeds where a rank vegetation has been growing.

When a current, a general motion of men's minds, sets in toward some definite goal, then it becomes the duty of all those who are their leaders to choose the proper routes with earnestness and conscientiousness. If a good intention in behalf of some object is wrongly directed, it soon turns against the object itself; all those who allowed themselves to become interested therein turn away discouraged as soon as they believe that their good intention has been wasted to no purpose, and hence those unlimited reactions and rebounds in public opinion. I believe that I am under a moral obligation to speak out in this place. I do it here, perhaps, more confidently than anywhere else, because I feel that here I am understood. I feel it, through the very fact that I have been requested to give my lectures before this audience. The request came to me from the Committee of the Albert Society, from its exalted Lady President. The existence of the Albert Society, its organization, its functions, its efficiency, and its authority, are ample proofs that the value of hygiene is understood here.

In this place I must also acknowledge that the Saxon Government was the first in Germany to establish a Central Board of Public Health; it has also included the teaching of hygiene in the teaching of military medical science. Such arrangements appear to me to be types of the two directions which must now be taken and followed out: on the one hand, investigation, observation, and experiment; on the other, systematic personal teaching. These are the only two ways which lead to the goal.

You have been enabled to see, from that single subject I have treated, how much remains to be done and created; everything is still insufficient and incomplete, and has to be developed and determined. Think of the great chapters—air, clothing, dwelling, ventilation, heating, lighting, building-places, and soil—their relation to air and water, and their influence on the course of disease; epidemics, and protection against them; drinking-water, and its distribution among the population; alimentations and articles of food; the maintaining of different classes of men under different circumstances; dietaries; public baths; gymnastics; collection and removal of excrementitious matters and refuse from households and trades; drainage; disinfection; inspection of dead bodies and their interment; unhealthy trades and manufactories, schools, barracks, asylums, hospitals and nursing, prisons, health statistics, etc.

There is not one among these departments of hygiene in which nothing is left to be done; in most of them the work has scarcely begun. There has always been a desire for and an aiming at health; but ideas about it have changed completely. The former supports of hygiene have crumbled away in the powerful analytical solvents of modern physiology; very little has remained; everywhere new foundations are necessary. This requires workmen; the season appears favorable—do not let it pass unemployed.

It is not sufficient to build up correctly a series of hygienic truths, which might be the work of a few; these truths must be brought to bear upon life, and this requires instruments. Three professions are in real life the natural trustees and representatives of the hygienic interests of the community—physicians, architects, and engineers, and also the public administration. There must be harmonious action between them; good intentions are not sufficient; there must be knowledge and power. Only good musicians can make good music, and they must be well taught and practised. The institutions at which the members of these professions have received their education have all the while generally ignored hygiene as an independent branch of study. A vague supposition left it to the individuals concerned to take the trouble of gathering for themselves whatever was known or would be made public about matters of hygiene. Lectures on forensic medicine were supposed to be sufficient, but they have to consider facts and evidence only with regard to penal laws, which themselves result from the old and highly-cultivated science of jurisprudence. Hygienic laws must spring from hygienic science, and there was none.

Many of the existing hygienic laws and regulations cannot be kept up if examined by the light of hygienic science as it is now. It is no good going on issuing public regulations, demonstrative of good intentions, for the public health; the right thing is to create a firm basis for practical purposes and public measures. Hygiene must become an independent branch of study, to be taught by special teachers at universities, medical and polytechnic schools, not without the help of proper laboratories. Systematic instruction must be offered to students and practitioners of medicine, to members of the civil or municipal service, to architects and engineers. Books and reading can as little occupy the place of personal teaching and experimental investigation as a medical book in the library that of the physician, or a hand-book that of the public chair. The self-taught hygienist has frequently to look out for principles on which to act, while he is called upon to act at once, and routine alone is a dangerous and unreliable assistant. There are exceptions—brilliant ones even—but exceptions prove the rule.

The increasing interest taken by the intelligent and well-meaning members of society in matters of public health, which have also an

intimate connection with the public purse, cannot fail to assist the whole movement which is taking place in favor of hygienic science and its independent and well-endowed instruction.

The whole movement is still going on, but not without resistance here and there. This resistance shields itself, sometimes, behind the pretext that there are at present not enough well-qualified teachers. Certainly the beginning has its difficulties, but everything must have its beginnings. This was the case with the first periodical in Germany for public hygiene, founded by Dr. Varrentrapp, which has achieved an entire success, in spite of all misgivings and discouraging vaticinations before it was started. Worthy representatives of the neglected science will be found for teaching it, as soon as a serious demand manifests itself. A certain species of medical men will be quite made for it, after some preparation. Hygiene is, after all, nothing but applied physiology, with particular reference to the physical well-being of mankind. According to my experience, men of science and physicians, who are specially grounded in the practical and theoretical study of physiology, chemistry, and natural philosophy, are those who can most easily fit themselves for the special work of hygienic science. It is true, physiology includes the most essential points of hygiene, and physiology is an application of natural philosophy, chemistry, and anatomy. But as the votaries of the latter sciences have never done the work of pure physiologists, so these would never have done, and never will do, the work of pure hygienists. England has preceded other countries in the creation of professorships for hygiene. I confidently believe that the proper men, in sufficient number, will also be met with in Germany in a short time.

Should my lectures in Dresden have had the effect, in some degree, of turning your hearts and minds toward the most pressing tasks of hygiene, so that every one of you may do his best for them in his own sphere, then I am sure I have done something practically useful, and have not spoken in vain.

A BRIEF HISTORICAL SKETCH OF THE DISCOVERY OF THE CIRCULATION OF THE BLOOD.

By GEORGE JACKSON FISHER, M. D.

AMONG the great discoveries which the genius and patient research of man have developed, none lay us under more grateful obligations, in view of its practical value and admirable simplicity, than that of the circulation of the blood. Historians record the rise, progress, and decline of nations, the discovery of new countries, and

the exploits of conquering heroes, and yet pass almost unnoticed the achievements of men of science. Few persons are at all acquainted with the history of when and how, through a series of successive revelations, this truly wonderful function came to be thoroughly understood. It is a long and delightful story if followed through all its details, which I shall, however, endeavor to cut short in relating it to persons outside of the medical profession. We are obliged to glance back through several centuries and make the acquaintance of nearly a score of anatomical celebrities, who have each contributed some observation or discovery leading to the final comprehension and complete interpretation of God's beautiful but simple method of circulating the vital fluid and keeping it ever replenished and pure.

The pathway to the climax of this discovery was not only long but rugged, hedged in by deeply-rooted errors, and obscured by rank prejudices ancient and wide-spread. The errors must be destroyed, the clouds dispelled, parts carefully observed; the explorers must work slowly and cautiously, and what is discovered must be explained. Thus it came to pass that anatomists discovered one thing after another, and little by little the light of truth dawned upon their minds, wherewith they saw and gave the world sensible ideas of the uses of parts, when eventually "the immortal Harvey," the crowning light, the clear-headed philosopher, the Newton of physiology, drew the simple chart of the double circulation. This event took place two hundred and fifty-seven years ago, for it was in 1619 that Harvey completed the discovery. He made no haste to tell the world what he had done, except what the individuals of his classes learned from his lectures, for he taught his discoveries ten full years before he published his modest but wonderful little book "Concerning the Motion of the Heart and Blood in Living Creatures," printed in Latin at Frankfort-on-the-Main, in a thin quarto of only seventy-two pages, in the year of grace 1628.

I propose to give a brief account of the antecedent errors and discoveries to the time of Harvey—that of Erasistratus, who taught that the arteries were air-vessels; of Galen, who demonstrated that they are blood-vessels as well as the veins; of Vesalius, who convinced the world that Galen erred in declaring that holes existed in the partition between the two sides of the heart; of Servetus, Columbus, and Cæsalpinus, who, quite independently of each other, discovered the circulation through the lungs; of Fabricius, who discovered the valves in the veins; of Harvey, who first comprehended the entire circulation; of Asellius, who discovered the lacteals; Pecquet, the receptacle of the chyle; Rudbeck, the lymphatics of the liver; and, lastly, of Thomas Bartholin, who discovered the lymphatics of the whole body.

Erasistratus (300–260 B. C.), a Greek physician and anatomist, of Iulis (the modern Zea), in the island of Ceos, was the grandson of the

illustrious Aristotle, being the son of one of his daughters. It is said that he was so fond of anatomical pursuits that he retired from his practice in Alexandria, where he had settled, the better to gratify his taste. He wrote several treatises which are lost, and all we possess of his writings are a few fragments preserved in the works of Galen. From these we learn that he gave names to the auricles of the heart. He declared that the veins only were blood-vessels, and that the arteries, as their name implies, were air-vessels. The sole purpose of breathing was to fill the arteries with air; the air distended the arteries and made them beat, the air caused the pulse. The air, once in the left ventricle of the heart, became the vital spirits. The office of the veins was to convey blood to the extremities. When the veins carried blood only and the arteries were filled with vital spirits, then perfect health was maintained; but the entrance of blood into the arteries, which he admitted to sometimes occur, was abnormal and the source of disease—fevers when it entered some noble part or into a great artery, and inflammations when it was found in the less noble parts or in the extremities of the arteries. Thus it is seen that a stupendous error was established on a mighty authority. This error was destroyed by Galen four hundred years subsequently to the time of Erasistratus.

Claudius Galen (A. D. 131), next to Hippocrates the most celebrated physician the world ever produced, was born at Pergamus, in Asia Minor, about the year of our Lord 131, and educated in anatomy and medicine at Alexandria, then the most famous school in the world. At the age of thirty-four he settled at Rome, where he distinguished himself as a skillful practitioner, and became the physician to the Emperor Marcus Aurelius. The period of his death is not known, but it is stated that he was still living in the reign of Septimius Severus. Galen was a voluminous writer. A considerable number of his works are lost, and yet eighty-two treatises, more or less complete, survive and are in print. The writer of this sketch felicitates himself in the possession of a fine copy of the "Editio Princeps," in five ponderous folios, printed in Greek, by the celebrated Aldine press, at Venice, 1525. For a period of nearly fourteen centuries this vast mass—more voluminous than the entire Bible—was copied and recopied with the pens of scribes! Who can duly appreciate the value of the press? Galen proved that the arteries are blood-vessels, and thus destroyed the error of Erasistratus. He said, when an artery is opened, blood alone gushes out and no air. He tied an artery at two places a little distance apart, and on opening the vessel found it filled with blood only. The followers of Erasistratus wanted to know how the air from the lungs entered all parts of the body, to whom Galen replied that the air entered the lungs to cool the blood, after which it was expelled. This theory was held so late as the last century, even by the renowned physiologist Albrecht von Haller. Galen declared the pulse to be the

dilatation of the artery by the contraction of the heart, which is the truth.

Galen also taught that there are two kinds of blood, the *spiritual* blood of the arteries and left ventricle, and the *venous* blood of the right side of the heart and veins, the red and the black blood. These were great strides in the right direction, and yet this wonderful genius was the author of some grave errors. He believed it necessary that a certain portion of spirit should be mixed with the venous blood to render it fit for nutrition, and this he conceived took place by the transmission of arterial blood through little holes in the ventricular septum which he called "foramina." He taught that the arterial blood nourished organs of a light and delicate texture such as the lungs, while the venous blood nourished the grosser organs, such as the liver.

The early modern anatomists believed the septum was perforated, and saw with the eyes of faith the "foramina" on account of their unquestioning confidence in the infallibility of Galen as an authority. Mondinus, who flourished in the fourteenth century, the first anatomical writer after Galen, said the septum was perforated, and twenty others reiterated it.

Berrenger de Carpi, who wrote and published his anatomical work in 1521, was the first to waver, and say that the openings in the septum *were only to be seen with difficulty.*

That I may pass no one who has been credited by any writer with even the least knowledge of the circulation, or who has even hinted a better understanding of it than those already mentioned, I come next in the order of time to NEMESIUS, who was Bishop of Emissa, a city of Phœnicia, at the latter end of the fourth century. He was not properly a medical writer, though he wrote a treatise concerning the "Nature of Man." The editor of the Oxford edition of this work (1671) contends that Nemesius understood and described the circulation of the blood in plain terms; while Dr. Freind, in his "History of Physic," denies that he had anything more than a vague notion of this function. I copy the words of Nemesius as translated by Freind for the benefit of the curious:

> "The motion of the pulse takes its rise from the heart, and chiefly from the left ventricle of it; the artery is with great vehemence dilated and contracted, by a sort of constant harmony and order. While it is dilated, it draws the thinner part of the blood from the next veins, the exhalation or vapor of which blood is made the aliment for the vital spirit. But, while it is contracted, it exhales whatever fumes it has through the whole body, and by secret passages. So that the heart throws out whatever is fuliginous, through the mouth and the nose by expiration."

Thus it appears that Nemesius had a little insight of the circulation 1,500 years ago, yet so imperfect that he neither comprehended it himself nor made it understood by any who followed him.

Andreas Vesalius, of Brussels.—The next great actor on the stage, comes the renowned Vesalius, the Luther of anatomy, the bold and defiant reformer, who, by persevering diligence and pains-taking observation, corrected the numerous errors of all his predecessors, and notably those of Galen. This wonderful young man, before he attained the age of thirty, published the most extensive, accurate, and in every sense the most magnificent work on human anatomy the world ever saw; wealth was lavished on its illustration and sumptuous publication. Jan Stephan van Calcar, the favorite pupil and wonderful imitator of the world-renowned Titian (not Titian himself, as some have declared), was employed to design anatomical figures, and the best engravers cut them in wood to adorn that massive and splendid old folio—that *opus magnum*, which was published in Basel, in the year 1543, three and a third centuries ago.

It is the delight of the medical bibliomaniac to procure a good copy of this rare book. The writer of this essay sought vigilantly for a score of years, failing to secure it until quite recently, and then from the library of a deceased friend, who was an ardent lover of the medical classics. He too had sought in vain for this book, and at last, after long rummaging the dusty and mouldy antiquarian book-stalls of many an ancient city in Europe, laid his hands upon a fine copy of the "Corporis Humani Fabrica," which he ever after regarded as the gem of his collection, as it certainly now is (almost sacred by melancholy association) the greatest treasure of my own. I wish we had time to stop just here, that I might give you a sketch of the life of Vesalius. Henry Morley, Professor of English Literature in the University of London, has written a lively and lovely little biography of this great anatomist, which is far more fascinating than any romance.

The great Vesalius, justly styled "the father of modern anatomy," subjected the septum, between the right and left cavities of the heart, to a thorough scrutiny, and found that no holes existed in it, and then had the boldness to declare the truth in spite of the previously unquestioned authority of Galen, whose writings were sacred in the estimation of all physicians. Thenceforth anatomists ceased to believe and teach this great error which Vesalius dispelled and swept away, and thus it came to pass that the second great step was taken toward the discovery of the circulation of the blood.

On the 27th day of October, in the year 1553, on a hill not far from the old Swiss city of Geneva, could be seen a motley gathering of anxious and excited men, women, and children, and among them a goodly number of learned doctors of divinity, chiefly Protestants, conspicuous among whom was John Calvin, all assembled to witness a scene of extreme horror. There stood, lashed to a post, a scholar past forty years of age, who in his time had imbued himself in the learning of three professions—law, divinity,

and medicine. Of his attainments in jurisprudence I know nothing; of his anatomical and physiological knowledge I will say more anon, merely premising that it was truly marvelous and in advance of the times; in theology, according to the opinion of Calvin and others, he was a heretic, since he entertained antitrinitarian notions. He had written two books, the respective titles of which are, "De Trinitatis Erroribus" (1531) and "De Christianismi Restitutio" (1533), which latter he had the frankness to send to Calvin for corrections and suggestions. Calvin denounced it promptly to Cardinal Touron as heretical, whereupon the cardinal laughed heartily at one heretic accusing another. It has been said, and it is to be feared with too much truth, that John Calvin was stirred not so much with holy zeal or fanaticism as by hate, as he had received a letter from this medico-legal theologian, now tied to the stake, awaiting the horrid tortures, and death, by slow fires about to be kindled at his feet, which letter animadverted, perhaps not very sweetly, upon the errors and absurdities of Calvin's "Institutes." This letter, be it understood, was in reply to a violent one which Calvin had written to this poor victim concerning his opinions. Time will not allow me to tell the whole story of how Calvin vindictively threatened him, and drew up thirty-eight articles of accusation against him, and how the poor, unfortunate man fled and disguised himself, and was subsequently arrested and tried by a grave council of sixty, who, after deliberating three full days on his heresy and the degree of punishment to be inflicted, fixed upon a heavy fine, and death by slow, torturing fires; and that all his manuscripts and copies of his works were to be burned with him and to furnish a part of the fuel with which to execute this fiendish sentence. Yet so it came to pass that this unfortunate scholar expiated his crime of heterodoxy in this tragical manner, and so effectually was the order for the burning of his works carried out, that only a single copy of one of his books is now believed to be in existence, and that is not a little scorched by fire.

You may wonder who this poor victim was, and why he is introduced here in a sketch of the history of the discovery of the circulation of the blood.

It was MICHAEL SERVETUS, whose Spanish name was Miguel Servede, born in the year 1509, at Villanneva, in Aragon near Saragossa, in Spain. He was educated, as before hinted, in three professions, in jurisprudence and theology in the University of Toulouse, in medicine at Paris. He practised as a physician, and wrote at least one medical treatise. He also wrote, most unfortunately, two theological books, one an abstruse metaphysical work, already alluded to, "The Restitution of Christianity," which, though it ended in his ruin, contained words and ideas which have immortalized his name. Of this wonderful book a copy exists in the Bibliothèque Impériale at Paris, of which M. Flourens, Perpetual Secretary of the Academy of Sciences, proudly says,

"I have seen, I have touched, the book of Servetus!" He then goes on to state that it is perhaps the only copy now in existence; that it belonged to Colladon, one of the accusers raised up by the pitiless Calvin against the unfortunate Servetus; that this copy formerly belonged to the celebrated English physician Dr. Richard Mead, and was afterward purchased by the Royal Library of France at a very high price. In it, says Flourens, Colladon has underscored the passages upon which he accused Servetus; and that, finally, as a last mark of undeniable authority, several pages of this unlucky volume are scorched and blackened by fire. It was not saved from the pile where author and work were burned together until after the conflagration had commenced.

In this rare book is contained the first account ever written of the pulmonary circulation. I will not stop to quote the exact words as I have them in translation, but will briefly state that, in plain and unmistakable language, he declares that all the blood is sent by the contraction of the heart from the right ventricle through the pulmonary artery into the lungs, where it is changed from dark to red in color by the atmospheric air, and thence returned to the left side of the heart through the pulmonary veins—which is strictly true. Servetus denied the old doctrine of Galen, that the liver was the seat of sanguification, and declared it to be the lungs.

Thus it is seen that, long before the day of Harvey, there was a man of genius occupied with this great subject of the circulation of the blood, and that man was Michael Servetus.

I will add but a word to this sketch, already too long, in explanation of the occurrence of these physiological considerations in a metaphysical treatise of this kind. Servetus was discussing the Scriptural assertion that the soul is in the blood, that the soul is the blood itself; and hence, as Flourens states the case, "'Since the soul is in the blood,' says Servetus, 'to know how the soul is formed it is necessary to know how the blood is formed; and, to learn this, we must see how it moves.'"

But Servetus was not equally clear in his views of the general or systemic circulation. "He speaks confidently of the nerves being continuations of the arteries, and describes, with grave precision, how the air passes from the nose into the ventricles of the brain, and how the devil takes the same route to lay siege to the soul." [1]

Realdo Columbus (1544–'77).—This celebrated anatomist, one of the best of that illustrious line which gave glory to the medical school of Padua in the sixteenth century, was a native of the city of Cremona, which is about fifty miles from Milan, in Italy. He flourished about the year 1544, and was a pupil of the renowned Vesalius. Columbus made several important discoveries and improvements in the knowledge of anatomy. He rediscovered the *pulmonary circulation*

[1] "*Blackwood's Edinburgh Magazine*, August, 1858, p. 151.

six years after Servetus's ill-fated book was printed, and unquestionably without any knowledge of what was in it; for it does not appear that the discovery by Servetus was known to the world, or produced any influence whatever upon any individual, owing to the character of the work in which it appeared, and to its thorough destruction by fire.

The description which Columbus gives of the circulation of the blood through the lungs is very complete, clear, and concise. "Between the two ventricles is the septum through which it is believed the blood passes from the right to the left; but this is a great mistake, for the blood is carried by the *arterial vein* into the lungs; thence it passes, with the air, by the *venous artery*, into the left ventricle of the heart, which no one has yet seen."

His work, "De Re Anatomica," was published in 1559. Columbus died in 1577.

Andreas Cæsalpinus (1519–1603).—This third aspirant for the glory of discovering the pulmonary circulation was born at Arezzo, thirty-eight miles from Florence, Italy, about the year 1519. He was an eminent philosopher, a celebrated botanist, and a distinguished physiologist. He was for many years a professor at Pisa, and subsequently called to Rome, where he also professed, and received the appointment of first physician to Pope Clement VIII. He spent the last years of his life in Rome, where he died February 23, 1603.

The great naturalist Linnæus styled Cæsalpinus the first systematic writer on botany, and followed his classification in many particulars, making it the basis of his own. The history of the physical sciences gives more than one example of the discovery of an important fact by two or more persons, in different places and at different dates, each without previous knowledge of what the other had observed. So do we find it in this instance. Cæsalpinus rediscovered the pulmonary circulation without knowing that both Servetus and Columbus had each previously and independently discovered the same, for he nowhere alludes to them; and he was too noble and honorable a man to bedeck himself with glories not his own.

Moreover, this man was the first who ever employed the felicitous and expressive words, "the circulation of the blood."

"This *circulation*," said he, "which carries the blood from the right heart through the lung into the left, corresponds perfectly with the disposition of the parts. For each ventricle has two vessels: one by which the blood arrives, and the other by which it departs. The vessel by which the blood arrives at the right ventricle is the *vena cava;* that by which it leaves is the *pulmonary artery.* The vessels which pour the blood into the left ventricle are the *pulmonary veins;* the vessel which affords it exit is the *aorta.*"

No man can describe it more accurately. But Cæsalpinus did not stop here. He was the first and only one before Harvey who gave the

world any idea of the circulation of the blood through the entire body. He pointed out the familiar fact that the veins swell below and not above the bandage tied around a limb, which demonstrated that veins return the blood to the heart and not toward the external parts of the body. He also says, "The blood conducted to the heart by the veins receives there its perfection, and, this perfection acquired, it is carried by the arteries to all parts of the body."

Certainly no man can describe the general circulation more concisely or better than this.

Thus it appears in evidence that, over half a century before Harvey's discovery, Andreas Cæsalpinus lifted the veil which concealed the mysteries of Nature, sufficiently to obtain quite a clear understanding of both the lesser and the greater circulation of the blood.

His countrymen are determined to proclaim his priority, and contest the claims of Harvey for the right to wear the laurels, as will appear from the following extract taken from a recent medical journal: [1]

> "A monument in honor of Andrea Cesalpino was unveiled in the University of Rome, October 30, 1876, with imposing ceremonies. The Italians claim for Cesalpino the merit of having discovered the circulation of the blood more than fifty years prior to Harvey's discovery. Dr. Giulio Ceradini, Professor of Physiology in the University of Genoa, seems to have been the orator of the day, and he recommends that over the entrance of the Pisa school, where Cesalpino first taught his discovery, there be placed the following inscription: 'Andrea Cesalpino, of Arezzo, Lecturer on Medicine in the University of Pisa, after the correction of Galen's errors as to the function of the liver and the veins, discovered the circulation of the blood through the whole body, which circulation he made manifest by vivisections after ligatures had been applied to the veins, and which in his "Quistioni Peripatetiche" and "Quistioni Mediche," published in 1569 or 1593, using the word "circulation" itself, he fully described. Ill-advised was the English Harvey, who, in 1628, dared to arrogate to himself the discovery of this mighty truth.'"

Hieronymus Fabricius ab Aquapendente (1537–1603).—Jerome Fabricius was very celebrated in his day. The republic of Venice settled upon him a yearly stipend of a thousand crowns in gold, and honored him with a statue and a golden chain; but his immortal honor consists in having discovered the valves of the veins, the anatomical proof of the circulation, and in having been the teacher of Harvey.

He discovered the valves of the veins in 1574. He saw that they open toward the heart, and that the blood could only move in that direction, the reverse of what takes place in the arteries, which have no valves. Fabricius saw the fact, but did not understand the proof it furnished that the blood moved in a continuous circuit.

The March and April numbers of the American reprint of the London *Lancet*, of 1877, contain two little articles, by Sampson

[1] New York Medical Journal, December, 1876, p. 667.

Gamgee, entitled "Harvey and Cæsalpinus: an Historical Fragment," from which I learn that Prof. Ercolani, of Bologna, has brought forward another claim for the great honor of discovering the circulation, and has urged with so much erudition and persistence, on behalf of Carlo Ruini, that, *in memoriam*, a marble tablet adorns one of the halls of that ancient seat of learning. It would appear that Senator Ruini's work, "Anatomia del Cavallo," published at Bologna, in quarto, 1598, and at Venice, in folio, 1599, had but a limited circulation, and remained comparatively unknown. Dr. Gamgee says: "This marvelous passage, so far as I know, never attracted attention until my friend Prof. Ercolani set it forth, with justifiable national pride." I regret that Dr. Gamgee has not copied "this marvelous passage."

I will pass Fra Paolo Sarpi, theologian and anatomist, born at Venice in 1552; and La Vasseur, a disciple of James Sylvius, the very worthy master of Vesalius, and in turn his fiercest adversary—to both of whom has been attributed the honor of having discovered the circulation of the blood. Their claims rest on uncertain data, a critical examination of which would be out of place in an essay of so brief and popular a character as this; hence, having alluded to them, I will proceed to the so-called "immortal Harvey," on whom all English writers bestow the glory of having first discovered the circulation, and first published to the world the demonstrations of the great fact.

William Harvey (1578–1657).—I will be brief in my sketch of the crowning hero of the story of the circulation of the blood. William Harvey was born of a highly-respectable Kentish family, April 1, 1578—wanting one year of three centuries ago. Great men have chiefly come of superior and noble-minded mothers. I cannot pass the quaint and lovely moral portrait inscribed on the monumental tablet, in Folkestone Church, believed to have been written by Dr. Harvey himself:

"A. D. 1605, Nov. 8th, dyed in y^e 50th yeere of her age, Joan, wife of Tho. Harvey. Mother of 7 Sones and 2 Daughters.

A Godly harmless Woman: A chaste loveing Wife:
A charitable quiet Neighbour: A co'fortable friendly Matron:
A p'ovident diligent Huswyfe: A careful te'der-hearted Mother.
Deere to her Husband: Reverensed of her Children:
Beloved of her Neighbours: Elected of God.
Whose Soule Rest in Heaven: her Body in this Grave:
To Her a Happy Advantage: to Hers an Unhappy Loss."

This man, so noted in physiological science as to be generally spoken of as the immortal or the divine Harvey, occupied in his time many positions of trust and honor. He was physician to St. Bartholomew's Hospital, London; Professor of Anatomy to the College of Physicians; one of the physicians of King James I., and subsequently physician in ordinary to "the most illustrious and indomitable Prince

Charles I., King of Great Britain, France, and Ireland, Defender of the Faith." He was with this king at the battle of Edgehill. Much of his time was occupied in attendance at the royal court, and yet he found opportunity to follow the bent of his genius in anatomical and physiological researches.

Being wealthy, he remembered the necessities of his profession, and munificently bestowed money in the erection of a fine edifice for the College of Physicians, enriched it with a fine pathological museum and library, and endowed it with funds, wherewith, as a part of the bestowment, an annual oration is delivered for the advancement of medical science.

But to return to the subject under consideration: methinks I hear you ask, after the foregoing recital of what so many observers have discovered, "What remained for this great man Harvey to discover or explain?"

Dr. Rolleston [1] answers: "Nothing less than *the circulation itself*. His predecessors had but impinged, and that by guess-work, upon different segments of the circle, and then gone off at a tangent into outer darkness, while he worked, and proved, and demonstrated, round its entire periphery."

True, as Flourens says, when Harvey appeared, everything relative to the circulation of the blood had been indicated or suspected; nothing had been established. Servetus knew nothing of the general circulation; Columbus adhered to the Galenic error of the origin of the veins in the liver; Cæsalpinus, who perceived the two circulations, and came so near to comprehending them, still held belief in the error of perforations in the ventricular septum; and, lastly, Fabricius—who, by-the-way, was not the very first to discover valves in the blood-vessels, but who discovered more of them than any other observer, and wrote more and better than any of his predecessors—Fabricius, I say, did not understand the use of the valves, supposing them to be for the purpose of strengthening the veins and checking the too rapid flux of blood through them.

The medical historian Sprengel has cunningly remarked that nothing explains Harvey better than "his education at Padua," under the teachings of Fabricius.

If it was a piece of good fortune for Harvey to enjoy the teachings of Fabricius, it was a happy thing, and a thrice fortunate thing, for the world, that the study of the circulation should have fallen into the hands of a man so well fitted to investigate it and to elaborate the true theory of the motion of the heart and blood.

Before Harvey, it was not known that the heart is the motive power—it was presumed to be the lungs; he it was who demonstrated every step in the progress of the blood in its double circuit, stilled all clamor of disputants, and convinced the world that he was right.

[1] "Harveian Oration" for 1873.

Let every man who has in any manner contributed to the final discovery have his just proportion of credit for what he has done, but let no man try to rob Harvey of the glory, which is rightfully his, of having perfected our knowledge of this wonderful function, modestly, lucidly, and with great forbearance and dignity, in view of the unkind opposition and even vindictive hatred which his teachings engendered.

John Aubrey,[1] who was at Harvey's funeral, and "helpt to carry him into the vault," tells us he had heard him (Harvey) say "that after his booke of the circulation of the blood came out, he fell mightily in his practice; 'twas believed by the vulgar that he was crack-brained, and all the physitians were against his opinion and envyed him."

I cannot follow the history of the opponents to Harvey's new doctrines. I will mention a few of the most potent, beginning with Primrose, of Scotland; Parisanus, of Venice; Caspar Hoffmann, the learned and laborious professor of Nuremberg; Joannes Veslingius, professor at Padua; and end with Riolanus and Guy Patin, of Paris. Neither will time permit me to more than mention a few of the powerful defenders and promulgators of this new doctrine, as it was always called, among whom were Roger Drake, his own countryman; Werner Rolfink, professor at Jena; Renatus Descartes; Sir George Ent, his biographer; and Peter Dionis, who taught it in the *Jardin du Roi* by order of Louis XIV.—all praise be to this King of France.

Dionis says, "I was chosen to demonstrate in your royal garden the circulation of the blood and the new discoveries, and I acquitted myself of this duty with all the ardor and the exactitude which the orders of your majestic deserve."

All this looks as if the predecessors of Harvey had failed to discover or to teach the true motion of the heart and blood. It was twenty-three years after Harvey's publication that Italy, which now claims the entire credit of the discovery, admitted the truth of the new doctrine; and about the same time John Pecquet, of Dieppe, and Thomas Bartholin, the Dane, gave in their adhesion to the new doctrine, and spread it far and near in their writings. The victory was complete when Plempius, of Louvain, who had fought Descartes so valiantly, made the following retraction:

> "This discovery did not please me at all at first, as I publicly testified both by word of mouth and in my writings; but, by-and-by, when I gave myself up with firmer purpose to refute and expose it, lo! I refute and expose myself, so convincing, not to say merely persuasive, are the arguments of the author; I examine the whole thing anew and with greater care, and, having at length made the dissection of a few live dogs, I find that all his statements are most true."

Harvey knew nothing of the capillary vessels; these were demon-

[1] Aubrey, "Lives of Eminent Persons," 8vo, London, 1813.

strated by Marcellus Malpighius, who was born the very year that Harvey's work was published, 1628.

I will conclude my long story by merely mentioning the discoveries of the lacteals, the receptacle of the chyle, and the lymphatics.

Harvey discovered the circulation in 1619, and published it in 1628. Aselli discovered the lacteals in 1622; Pecquet the receptacle of the chyle in 1648; Rudbeck and Thomas Bartholin the lymphatics between 1650 and 1652. This was a glorious period indeed!

Thus it came to pass that the united labors of all these worthy men—and labors they were, and worthy men were they—resulted in giving the world a simple, clear, and satisfactory solution of the manner of the circulation of the nutrient fluids of the body.

Next all-fools-day will be the tercentenary of Harvey, when all Christendom ought to be interested in the justice of his claims to the glory of consummating a discovery of so much consequence to mankind. No mere national pride should bias the minds of men whereby memorials may be placed at Rome, Pisa, and Bologna, in rivalry with that which is to be erected at Folkestone, in England, to commemorate the time and place of Harvey's birth.

OVER-CONSUMPTION OR OVER-PRODUCTION?

By O. B. BUNCE.

WHY does the prevailing business depression continue? Why are the times so "hard?" Why is the long-hoped-for revival of trade so backward? What is it that has put the times so disastrously out of joint?

Every one is asking these questions, and nearly every one is ready with an answer. Some will declare that the trouble is all of the greenbacks; others will go so far as to affirm that the lack of greenbacks is the cause. Almost every one will assert that over-speculation has something to do with it; some will attribute the whole mischief to the intense railway "craze" of a few years ago, and the consequent losses. Not a few are confident that extravagance and over-trading are the explanation. There seems to be no general agreement of opinion; even men of equal business knowledge and experience differ essentially in their views as to the genesis and remedy of the evil, and the professors of political science are scarcely nearer of accord.

There has recently come from an eminent English authority in political economy an authoritative declaration in the matter. No one will deny that Prof. Bonamy Price's essay denominated "One per

Cent."[1] is eminently readable; the professor knows how to give literary grace and vivid interest to a theme commonly considered "dry;" it is further true that anything he may utter on the topic is entitled to great respect and consideration. At the same time there is no reputation so exalted that the assertions and arguments made public under its sanction should not be and may not be examined and tested. Now, to our mind Prof. Price is often logically wrong in his essay referred to; we can but think that many of the reasons he assigns for the great business depression—which now prevails in America, England, and Germany—are fallacious and misleading, and, with all modesty, it is our present purpose to give the reasons why.

The title of "One per Cent." is given to Prof. Price's article because one per cent. has been for some time the ruling rate of discount in the London money-market (just as from two to three per cent. has been for many months the quotation for call loans in Wall Street), funds in the hands of bankers being in excess of the needs of borrowers and traders. Trade is curtailed, production restricted, stagnation is evident in every branch of industry, and this general paralysis causes in the financial centres such a flow of money that it is offered to loan at an almost nominal discount.

The cause of this wide-spread depression, according to Prof. Price, is one, and one only—"over-spending, over-consuming, destroying more wealth than is produced. This," he says, "is the real *fons mali*, the root of all the disorder and the suffering, the creator of the inevitable sequence of cause and effect. Men have acted as a man who farmed his own land and had consumed not only the portion of the crops which were his true income . . . but had himself and his dependents devoured a portion of the seed-corn and the breeding-stock, had exchanged a portion of the produce which was required for wages in the coming year for foreign luxuries, or had consumed these necessary reserves on an excess of drainage, however valuable in itself and ultimately enriching."

This is the core of Prof. Price's argument. The prostration of trade has arisen from extravagance, he repeatedly declares. "The commercial depression, so long, so monotonous, so heavy, and so dull, came from the excessive consumption of English capital in unwarranted constructions beyond savings, and unwarranted expenditure in living by all classes, which destroyed wealth without repairing it with new productions."

But elsewhere he says: "Up to the extent of the savings of the nation, expenditure on railways can do no economical or financial harm; and these invaluable developers of wealth may on such a basis be rationally acquired for the public good. Any outlay made out of savings, be what it may, is innocent of mischief; it may do no good,

[1] *Contemporary Review*, London, and reprinted here in The Popular Science Monthly Supplement, No. 1.

but it does not impoverish. But what are savings? The surplus of wealth made over wealth consumed. If it is turned into capital and applied to increased production, the nation becomes richer; if it is expended on any luxury or any folly, the nation is where it is." These declarations no one, we imagine, will dispute.

But Prof. Price, in attributing business stagnation to extravagance, to "over-spending and over-consuming," assumes the whole question. He produces no evidence whatever in support of the attestation. He does not show that consumption and expenditure have exceeded production; he declares that capital has been impaired, but gives no facts nor figures in support of the affirmation. The whole groundwork of his theory is boldly and flatly assumed, without the slightest regard whether there is evidence to support it or not. It is grossly illogical to assume that there is over-spending simply because to casual observation there is high and extravagant living. A class may be extravagant; a group of people may be impairing their capital; but where are the figures to show that the English people as a whole have been indulging in undue excesses, have reduced the sum of their savings, "by which the means of producing are diminished?" There is absolutely nothing whatever upon which to base these assumptions! Prof. Price tells us in another place that "her (England's) producing power, her fixed capital, her machinery, remain unchanged," and that "she is compelled to shut up many of her factories, to dismiss or put on half-time immense numbers of her working-people, because there are fewer buyers of the articles they manufacture." This, he declares, is the very pinch of the matter. Indisputably it is, but whether fewer buyers is the consequence of over-consumption or of some other cause is also the pinch of the philosophy of the matter —and this let us ascertain, if it is possible to do so.

How is it, if the savings of a country have been really impaired, that capital at the same moment should be seeking investment at any rate of interest it can command—that all the financial centres are choked with an excess of money, for which it is impossible to find borrowers? Assuredly, loans at a low rate of interest imply an excess of capital over the needs of trade or production; it shows that business operations are restricted, for whatever reason, and have released capital from its ordinary uses to such an extent that it accumulates in trade-centres, seeking for borrowers that do not come. It can make no difference whether we call money capital or not; it cannot affect the heart of the question what it is that is offered at one per cent.—gold, notes, assets of any kind—whatever money may really be, it would seem clear that, if over-consumption had impaired the capital of the country, those individuals who could come into the field as lenders would be enabled to dictate terms to the needy borrowers. Over-consumption means a destruction of food, clothing, coals, metals, etc., to an extent that impairs the reserves of these

products; but it must be a marvelously extensive over-consumption that impairs the means for restoring them—that renders it impossible for fixed capital—machinery, furnaces, shafts—to be set in productive operation.

Can Prof. Price give an instance where any civilized nation, unless at war, or suffering from some great calamity, has impaired its capital by over-consumption? Can he name a period when, at the end of any year, with the exceptions mentioned, England has possessed less wealth than at the beginning of that year? When, in modern times, have a people impaired their capital by over-consumption? When and where has extravagance brought a community to ruin? Where are the instances? What are the occasions? Who can produce the statistics that will establish this theory? Not but what there may be, and often are, hurtful extravagance and speculative excesses; but these are usually special to a class. The great body of a people are rarely consumers to the extent they are producers; quietly, in a million of minor ways, the wealth of a country increases even in times of depression. We find current in the journals a paragraph which affirms that last year the valuation of property in England, exclusive of London, increased $14,335,000—too little, no doubt, but something different from the destruction of more wealth than is produced. Very rarely, indeed, if ever, has the capital of a country in normal periods of peace been really impaired, however much distress an imperfect distribution of labor and of profits may have caused.

Let us say here that the ordinary idea of national extravagance—meaning excessive expenditure by the people, and not governmental expenses—is peculiarly erroneous; an assertion we confidently make, notwithstanding the fact that Prof. Price accepts the usual theory. He declares that "a nation is only an aggregate of individuals," that "analysis will always resolve the action of the single man, and the combined coöperation of a host, etc., into the same constituent parts;" that is to say, over-spending and over-consumption are of the same nature, whether exhibited by an individual or a community.

Now, we think it can be shown that expenditure in the case of an individual and expenditure in case of a large group of individuals have certain very essential differences. When a community exchanges its goods for foreign luxuries to an extent to impair its productive capital, or has invested in railways or similar enterprises so as to reduce its working capital, it is in the position of an individual who has lived beyond his income. But the difference between an individual and a community is, that the income of the former is absolutely fixed, that of the other is wholly expansive. In truth, in an immense number of things, a *community is rich because it consumes, abundance being the product and consequence of extensive destruction.*

It is evident that the immense consumption of coal has made coal cheap and abundant. It has rendered possible the employment

of vast capital in the erection of costly machinery for the working of the mines, for the construction of adequate means of transportation, thereby making remote deposits accessible, and enabling capitalists to work the mines at the minimum of cost, which never would have been done had not the vast consumption of coal rendered it wise and practicable to do so. It is true the consumption of coal is increased by cheapness; but it is only by extravagance, so to speak, by free and extensive use of coal, that the machinery by which it is made cheap is put in operation. We have an immense wealth of coal because we consume coal so extensively; if we used but little we should have little, and this little would be dear.

This rule works in all or nearly all our staples. Cotton fabrics are a marvel of cheapness and abundance. The consumption and the possibilities of extended consumption have stimulated invention and industry so greatly that the world has become wealthy in its supply of this staple alone. Rarely, indeed, is there a woman so poor that she cannot own a calico gown; few are the men so destitute as to be without cotton shirts. We have this staple in almost unlimited abundance, as the direct result of the most extended consumption. It is the same thing with wool, with flax, with paper, with iron, with brick, with many other things.

So peculiarly different is the operation of expenditure with a community from that of an individual, that it is worth while to trace it still further. Let us suppose a town about to erect a grand cathedral, or some other public structure that requires a very large quantity of stone. At first flush it would seem as if a great deal of valuable material would be used in a purpose unnecessary and unproductive; but, as a practical fact, the building-material is likely to become more abundant and cheaper than it ever was before. The unusually large consumption of stone would lead either to the opening of new quarries or the erection of improved machinery for working the stone, and to the construction of railways, boats, etc., for facilitating its transportation; so that stone for building purposes would thereafter be cheaper and more abundant as the consequence of what at first sight appeared a wasteful consumption. In all staple things, at least, a nation is richer because it consumes, while a man is richer by what he saves. We are better housed, better fed, better clothed, we have a thousand things of taste and pleasure, because our eager and devouring appetites have stimulated energy, skill, invention, to their utmost to cater for us.

We say nothing as to which is the wisest direction for consumption to take, with all it stimulating power; we do not deny that consumption may make champagne, diamonds, silks, broadcloth, fine furniture abundant, at the cost of more useful and desirable things. The thing is simply that the energy, the zeal, the exertion of men are so expansive, that great demand compels to great production; and, of course,

we understand the economic principle that there can be no production without capital; that if the working reserves of a community are really impaired, the productive force is also straitened.

It will be said that consumption is rather the product than the cause of abundance. Undoubtedly, use is greatly increased by abundance; there is, in fact, action and reaction, the one stimulating the other. It will also be adhered to by some that capital is the sole source of production. Assuredly capital is not fixed in activity, nor are human energies rigidly limited; and as the resources of Nature are fairly boundless, wealth is wrought out of her bowels in our mines, and extracted from her chemistry in our fields, to an extent immensely determined by the demands of consumers. In the old fable of the purse of Fortunatus a gold piece appeared as rapidly as the contents were withdrawn; in the new purse of Fortunatus, called production, two or more pieces appear as rapidly as one is withdrawn; but we must not lose the purse, which let us consider as capital.

There is something more to be said about national extravagance. What is it that railways, and bridges, and canals, and fine buildings, cost? We hear continually the money-price mentioned. This is most misleading. The price paid is simply a sum of money that has changed hands; it represents the cost of the structures to those who built them, but not the cost to the community. What is this cost? What does a church or a railway cost the people as a whole? Some have paid wages, and some have received wages. This is only diffusion. Some money has gone for stone, iron, and timber, but this is only diffusion. The community is less this iron, stone, and timber,[1] but we have already seen that, as the production of this material is unlimited, no practical loss is inflicted here. It is asserted by all economists that food and clothing for the laborers are part of the cost. But the laborers would have been fed in any case, although they might have held on to their old clothes longer, had not the wage-fund been distributed among them. Now, to our mind, the real cost of this church or railway is the cost of the energy that might have been more profitably employed elsewhere. If all the productive industries are in full operation; if it is released labor, and the material is not required for more necessary purposes, then it cannot be shown that the church and railway have impaired the wealth of the community at all—that is, it cannot be shown that they have fundamentally cost the community anything. They were erected by released energies, by labor not otherwise required, and the community is not the poorer by a mite in consequence of their construction. A church may be a very extravagant undertaking for those who pay the money-price for it; the

[1] An exception must be made with timber. We are, in America, encroaching upon the forests, and hence consumption is now making this staple dearer; but, when all our hill-sides are covered with *planted* forests, the normal rule will operate in this product as in others.

railway may be a foolish and unremunerative enterprise; but this has to do with the individuals concerned; the community, in the suppositious cases we have made, *might*, let us suppose, have been better off had the expenditures of those individuals taken some other form, if the material and the labor had gone into something productive (let us believe there are other good things in the world than economic production); but no injury, no loss, no diminution of wealth has occurred—and this is the main thing. A passage quoted from Prof. Price in the earlier part of our article affirms this.

We hear a great deal about the railroad "craze" of a few years ago, and of the immense sums sunk in those foolish and extravagant ventures. But the sums of money commonly mentioned are misleading. As we have fully explained, the money simply changed hands; what was really lost by those enterprises was the goods and bullion exported to pay for the iron purchased abroad, and the food and clothing consumed by the laborers, over and above what their consumption would otherwise have been; in addition to which is the loss of the misdirected energy. This was all very large, no doubt; but far from being what the figures commonly quoted represent it to be. There is, moreover, no evidence that this loss was anything more than a part of our surplus; the assumption that it impaired our capital, and depleted our productive resources, is wholly groundless. No one can say, we imagine, that capital was withdrawn from any other pursuit; that productive industry in any direction was weakened by a secession of its resources by this "craze." The nation was much in the position of a merchant who has many ventures abroad, some of which have proved disastrous. His profits are reduced, but his ability to keep his numerous ships afloat is not impaired. Even had the railroad investments partially reduced our capital, it is really monstrous to assume that we could not have recovered from the blow in much less than four years of time. Whatever the cause of the business prostration may be, it evidently is something that lies deep, something far more serious than the loss of a part of our wealth. A merchant who loses all his profits is still enabled to go on; a merchant who loses even half of his capital is still enabled to go on: how is it, then, that the community is so nearly at a standstill because a portion of its surplus was lost? Distinctly the railway over-speculation, hurtful as it was, cannot account for the paralysis in industry which now, four years afterward, so generally exists.

Not a few people are convinced that paper-money is the cause of the difficulty. "Only return to specie payments," they say, "and all will be right." All the inflation and unhealthful stimulation caused by the greenbacks has ceased to be. It was predicted that a reaction must come upon the return to specie payments. It has come long before. It has come without contraction of the currency, the volume of which has ceased to exercise that hurtful influence that was supposed to

be inseparable from it. It may be asked, moreover, if the currency is the cause of our suffering here, how is it that a similar condition of business affairs exists in England, where the currency has remained unchanged? There is no doubt in the world that an inflated currency does have a hot-house effect upon trade and production, and, as with all forced things, a corresponding reaction follows; but it is wholly inadequate to account for the present difficulty, although it has doubtless contributed toward it.

What, then, is the real cause of the evil? In endeavoring to answer this question, we shall probably startle not a few well-established convictions; but we bespeak a fair and patient hearing.

Almost any practical man of business, upon being asked what the trouble is, would attribute it to over-production. To this the economist promptly exclaims that there can be no such thing. "What," he would say, "over-production! too much wealth! an excess of prosperity! The thing is impossible. No people ever yet was made poor by an excess of wealth, by a superfluity of goods." This seems very plausible; but, if the economist is pressed, he will admit that there may be, and often is, over-production in certain things—that more may be produced of special articles than there are goods of other kinds to exchange for them—but general over-production is, he will reaffirm, impossible. Inasmuch, however, as production is fairly never general, never uniformly active, there is always over-production in some branches of trade; and it so happens that this over-production is commonly coupled with great centralization of wealth and enormous appliances of machinery.

We must not be understood to utter a word against the power, the advantages, the immense boon of machinery; but, as all things have their compensations and their penalties, so machinery, beneficent and marvelous as it is, is one means of bringing about certain unfortunate consequences, as we think may be demonstrated.

Production and consumption do not have that intimate relation to each other they once had. In old times the weaver, for instance, was in contact with his customers: he wove cloth as he discovered the need; he cautiously set up a second loom when it became fully evident that it could be kept employed; and thus supply and demand went, as it were, hand-in-hand. But now gigantic mills filled with many spindles have little accurate relation to consumption. The power of production by means of improved machinery is something immense, and it is exercised with no very watchful or cautious regard to the immediate needs of the community. Goods are piled up in vast quantities in waiting for a future market, or for an anticipated change in price; or they are pressed upon the market at such low rates or on such long credits that buyers are seduced into over-purchases. In favorable times these establishments are run at high pressure. The old-fashioned nice relation between producer and

consumer disappears. Speculation takes the helm. Much more is produced than there is corn, leather, or other goods, to exchange for it. The resources of the mills are great; they can borrow from the banks while they pile up their fabrics in their ware-rooms; they can by means of their concentrated capital keep their machinery running, even at a loss, if by so doing they can crush out a rival or manipulate the market.

But in the height of this prosperous run there is a check—no matter for what cause—and suddenly the work stops. There is little sale for goods produced; the fires must be put out, the doors closed, and thousands of operatives are deprived of employment. This would not be so unfortunate if this over-production had been diffused among the work-people. But it had not. Notwithstanding the high pressure and the excessive manufacture, wages have been kept down; while producing in six months as much as could be exchanged in a year, the workmen have not been paid in this way—their wages have been upon the basis of the whole year's work—as a result, they are turned empty-handed upon the street. And, what is particularly unfortunate, they are reduced as consumers to the minimum point. Here the evil works both ways. The excessive production which has shut up the mill has weakened the power of the community to absorb this production—the goose that laid the egg has been slain.

Inevitably the recovery from hard times brought about in this way must be slow. The spindles cannot be set in motion until the stock of goods on hand is reduced and a fresh demand revives; this demand cannot revive because the great body of consumers are in a state of impoverishment. This condition of things is entirely sufficient to explain the genesis and the prolongation of business prostration. Capital is not impaired: it is locked up in machinery that is silent, in goods that cannot be exchanged, in money that has no borrowers. It is the paralysis of consumption that is the cause; and this paralysis has been brought about by an unregulated production, by an excess that is not diffused, by the stoppage of wages, by the idleness enforced upon those who would be consumers, by the absence of an adjustment of production to consumption. Is it not clear that we must have a regulated production; that machinery with its magical facility must be put in check; that we must restore the old cautious and intelligent relation between the two factors of supply and demand?

We read lately a very angry denunciation of a combination between certain mine-owners in Pennsylvania to limit the production of coal. Why? If these men are attempting to make an artificial scarcity, it is wrong, and all attempts of this kind fail; but if they mean simply to regulate the marketing of coal—of coöperating so that an excess of the article shall not be thrown upon the market, and prices forced below cost—they are right. It is better for them to

do this than in the heat of competition overstock the market, and then be forced to stop the works altogether, throwing all the miners out of employment. We should say that combination is just what is needed—so that the supply of material may be kept nearly on a par with the demand, and the mines uniformly worked at a sustained rate from one season to another. Spasmodic production is a dreadful evil. It is unfortunate for the consumer because it makes prices uneven, and it inflicts cruel injury upon laborers and operatives, and through them upon the whole community.

Here, then, is the evil. Speculation inflames it; currency inflation stimulates it; but undiffused, unregulated, and unrestrained production throws the whole complex machinery of trade out of order; it stirs the whole energies of the people into producing at one period, and arrests energies at another; in suddenly stopping production, it reduces consumption, and hence renders recovery the very labor indeed of Sisyphus. The only remedy we can discover is the wise coöperation of producers, the determination to put the production of goods in careful and just relation to the means possessed by the community for exchanging for them.

We hear recently a great deal of the example of France, and Prof. Price is among those who point admiringly to her in this crisis. Now, as every one knows, the savings of people in England, Germany, and America, are deposited in banks, whence they are loaned and become utilized as capital; in France the peasants hoard their savings in old stockings and secret corners. To withdraw from either of the former countries so large an amount as that of the indemnity paid Germany would greatly disturb trade; but the peasants, patriotically unearthing their hoardings of secret gold in exchange for government bonds, enabled the state, to the surprise of all, to pay her heavy penalty without distress or financial disturbance. But this was an exceptional position. We are scarcely to argue therefrom that hoarding is the true principle; that a nation is better off because its work-people hide their savings, withdrawing them from public use, rather than placing them in banks where they may become active capital. Prof. Price attributes the successful payment by France of the German indemnity to "the practice of one of the very greatest of economical virtues—she had saved." Now it was solely due to the *manner* in which her savings had been held. The fact seems to have dazzled everybody. The example of the French peasant is now held up on all sides—that he lives the narrowest and most restricted of lives; that his excessive economical spirit not only limits his comforts, but keeps him ignorant, superstitious, dull, spiritless, hopeless (the tragedy of the French peasant-life is only too well told in the pictures of Millet); that he has neither intellectual life nor any grace of art or refined civilization—these facts are nothing to the economist; the peasant has drudged and hoarded; he has refused himself and

his family ease and comfort, and hoarded; he knows neither art, nor literature, nor science, but he has hoarded; he lives a life scarcely better than that of the beast of the field, but he has hoarded; his savings have nourished no industries, nor rewarded any art, nor promoted any intellectual end, and he himself has done his best by mere restriction to limit the productive resources of his land—but having saved and hoarded with the instinct with which a dog hides a bone he is held up for admiration! This sort of thing fully explains the shudder with which people generally hear the name of political economy. It is true, there must be economy; there must be saving; but there is economy and economy. The real cause of the more prosperous condition of France is not starved existence but sustained and unspeculative production. There is less concentration there, less wild overtrading; there are more diffusion and old-fashioned relation of production to consumption.

This equable and uniform production is like a stream that is fed by ten thousand springs and many affluents; it flows steadily on, calm, perennial, beneficent: but our speculative and spasmodic production is too much like a mountain-river, that at one season comes down in a flood and deluges the land, at another subsides into a rivulet, and all the land is parched.

ATMOSPHERIC PRESSURE AND LIFE.[1]

By Dr. PAUL BERT,

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THE great influence that may be exerted upon living beings by atmospheric pressure is now questioned by none, and there is even a disposition to exaggerate its importance. If the barometric column rises or falls a few millimetres, nervous people affected with the asthma perceive phenomena, whether of a beneficial or of a noxious kind, which they do not hesitate to attribute to the weight or to the lightness of the atmosphere. But if this were the only cause of their sensations, then they should experience the same symptoms whenever they subject themselves to equal variations of pressure, as in passing from the level of the sea to a point only a few feet above it, or *vice versa*.

Rarefied Air.—As every one knows, in proportion as we ascend from the sea-level, the barometric pressure diminishes at the rate of about one centimetre per 100 metres of vertical ascent. And this diminution is progressive: suppose that at the sea-level the pressure is 76 centimetres, then it will be 66 centimetres at the height of 1,123 metres

[1] Translated from the French by J. Fitzgerald, A. M.

(summit of Vesuvius), 56 centimetres at 2,432 metres (pass of the Great St. Bernard), 46 at 3,998 metres (Mont Pelvoux), 39 at 5,920 metres (the height of the highest pass of the Himalaya is 5,835 metres). The greatest height attained by man was reached by Glaisher in a balloon — 8,840 metres, pressure 24.76 centimetres — and by the brothers Schlagintweit on foot, in the Himalaya, 6,882 metres, pressure 32 centimetres. The highest mountain on the globe, Gaurisankar, measures precisely 8,840 metres—the elevation at which Mr. Glaisher fell fainting to the floor of his car.

Such modifications of pressure cannot be endured with impunity by the human organism. Though life in moderately elevated regions, as the Jura and Auvergne, seems to be so beneficial to those who dwell there constantly, that multitudes come thither from afar in pursuit of health; and though in regions situated at a greater altitude, as the admirable plateau on which the city of Mexico stands, the sum of the climatic conditions seems to offer hygienic advantages: still all are agreed that at very great elevations there always supervene, with more or less intensity according to persons and circumstances, certain characteristic perturbations and discomforts described by travelers in the Alps, the Pyrenees, the Andes, and the Himalaya.

These are, first, a sense of fatigue out of proportion to the amount of walking or of work performed. The legs appear to become leaden, and one feels a weakness in the knees. Then the breath becomes short, difficult, labored; the pulse is quickened; the heart-beats occur isolatedly, and reverberate in the head. Next come singing in the ears, dimness of sight, and vertigo. The general sense of *malaise*, the feebleness, become such that the traveler must rest, else he will fall to the ground. Simultaneously there occur other symptoms having their seat in the digestive organs, such as nausea and vomiting. These various symptoms, taken together, constitute mountain-sickness (*mal des montagnes*), which bears a resemblance to sea-sickness.

When they first appear, a few moments' rest suffices to banish them; this instantaneous restoration of strength and vigor sharply distinguishes mountain-sickness from ordinary fatigue. But at greater elevations, where graver symptoms appear, such as bleeding from the nose or from the lungs, repose cannot bring back the condition of perfect health, though it always affords some relief. Travelers agree in saying that a person on horseback suffers far less than one on foot. On the high plains of the northern Himalaya, a rather brisk pace in walking, the ascent of a hill however low, the carrying of a moderately heavy load, suffice to exhaust one's strength, to cause him to faint, and in some cases even to produce death.

This is the reason why aëronauts are attacked much later than those who ascend the mountain-side. Ever since the day when Montgolfier, realizing the immemorial aspirations of the human race, gave to man the means of overcoming the gravity which ties him to the

earth, many a bold aëronaut has gone above the clouds. Only after they have reached the height of 6,000 metres do they usually experience symptoms resembling those of mountain-sickness.

But on land these symptoms make their appearance at elevations far lower, and differing according to locality. In the Alps, definite symptoms first appear at 3,000 metres; in the Bolivian and Peruvian Andes, at 4,000 metres; higher still, in the equatorial Cordillera and on the Himalaya. In general, the elevation at which they first appear depends upon that of the line of everlasting snow, the lower limit of mountain-sickness being situated a little above the snow-line. The influence of the temperature is very evident. As for anomalies special to circumscribed localities or to individuals, the consideration of them would take us beyond the bounds we have set for ourselves here.

These grave and curious symptoms have been explained in many different ways by travelers, physicians, and experimenters. As for the native mountaineers, they solve the problem of their origin by referring them either to supernatural intervention or to the influence of noxious effluvia. In the Andes these effluvia are reputed to be of an antimonial nature; in the Himalaya the cause is supposed to be vegetal poisons given forth from flowers, mosses, etc. These hypotheses need not detain us.

Among the many theories more or less tenable *a priori*, but none of which will stand the test of experiment, there is one which is almost universally accepted, and which reckons De Saussure among its distinguished supporters. It is known that the atmospheric pressure on a square centimetre of surface is 1.03 kilogramme. If we multiply this by the number of square centimetres of surface in a man's body, the product is something enormous. Take an average case, a pressure of say 15,000 kilogrammes. We are in equilibrium with this great pressure, they say; lessen the pressure, and the result is like the application of an immense cupping-glass over the entire surface of the body. The heart's action is now no longer sufficiently counterbalanced, and hence congestion and hæmorrhage of the mucous membranes and of the skin, engorgement of the blood-vessels of the face, cerebral troubles, and the rest.

It is amazing to find a theory so plainly at variance with elementary physical laws accepted by eminent men. What would be the result if we had to bear upon the surface of the body a pressure of 15,000 kilogrammes, and if every variation of the barometer added or subtracted from this sum one or two hundred kilogrammes?

Another theory, first offered by De Saussure, is far more worthy of attention. "On the top of Mont Blanc (4,810 metres)," says he, "the air is nearly one-half less heavy than at the sea-level; hence it results that if, in a given time, we pass through our lungs a given volume of air, that volume will represent only about one-half the weight of the same volume of the air to which we are accustomed. Hence there

must result insufficient respiration, or, more accurately speaking, insufficient absorption of oxygen." "The quickening of the respiration, which tends to offset the evil, is insufficient," says Martins, "for it would have to be twice as frequent, and have double amplitude, in order to compensate the diminution in the quantity of air inspired." Finally, Dr. Jourdanet adds that, "the pressure being reduced, the oxygen must be dissolved in the blood in a less proportion:" hence a pathological state analogous to anæmia, and which he calls *anoxyhæmia*.

These ideas have been met with many objections. In reply to De Saussure it was said that the atmosphere, even at half-pressure, contains a great deal more oxygen than is needed for respiration; and in reply to Jourdanet that, according to the researches of Fernet, oxygen in the blood being in the state of combination, and not of solution, its quantity does not depend on barometric pressure.

My own experiments show that De Saussure and Jourdanet are right. They further prove the sagacity of Jourdanet in recognizing in the inhabitants of the Anahuac plateau the injurious influence of low pressure which, though not perceptible in the state of health, reveals itself on the slightest attack of disease. I need not detail here the long series of experiments which have led me to conclude that the symptoms following diminished pressure, whether slowly or rapidly applied, are simply the result of a diminution of the oxygen in the blood; in a word, that they are nothing but a sort of asphyxia in the midst of the "pure and invigorating mountain-air."

Still I may repeat here an experiment which can be performed wherever we have a pneumatic apparatus; this experiment clearly proves that the lessening of the barometric pressure is of no account, mechanically, in the production of the phenomena. These are the result rather of chemico-physical action, the blood not being sufficiently charged with oxygen.

We place a sparrow in the pneumatic bell-glass *A* (Fig. 1), which communicates with the manometric tube *C E*. The pressure is gradually lessened by means of the tube *B*. When the manometer shows only 30 centimetres' pressure in the bell-glass, the bird gives pretty serious evidence of suffering; at 20 centimetres it totters, reels, and falls upon its side; at 18 centimetres it struggles violently, and would die in a few seconds, were I to leave it in this situation. So I quickly place at *a* an indicator, to show the height attained by the mercurial column, and, opening the cock *D*, I introduce into the bell-glass not air, but oxygen from the India-rubber bag *O*. At once the bird becomes himself again. I let it breathe a little while, and again I diminish the pressure as before. But now we reach 30 centimetres, 25 centimetres, without difficulty; not till we reach 20 centimetres does the bird appear to show some little signs of discomfort; we reach 13 centimetres, *a'*, a pressure much less than before, and yet the

life of the bird is plainly not at all endangered. If I were to admit oxygen once again, I might diminish the pressure still more.

Hence it appears that it is not the lowering of mechanical pressure that produces the symptoms, but the low tension of the oxygen of the

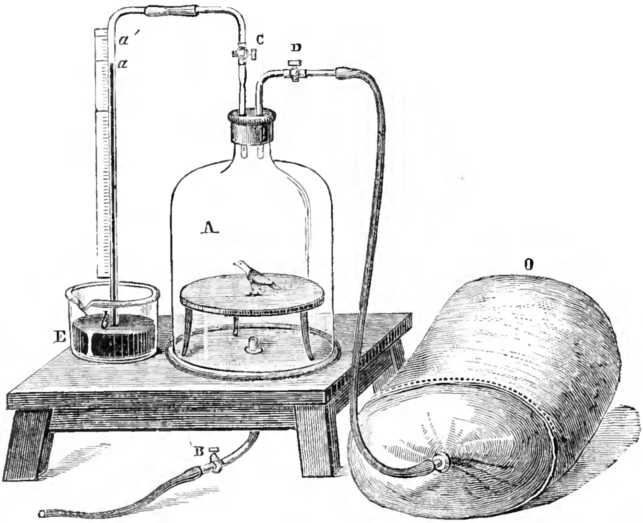


Fig. 1.

dilated air, which low tension prevents the oxygen from entering the blood in sufficient quantity.

This experiment I have made not only with sparrows, but also on my own person; and in the latter case the results are quite as striking as in the former, and I dare affirm, without vanity, no less interesting.

By the kindness and liberality of Dr. Jourdanet, I have been enabled to set up in the physiological laboratory of the Sorbonne great apparatus, by the aid of which I have studied the effects of compressed and dilated air. The dilated air-chamber consists of two cylinders of riveted sheet-iron, from which the air is gradually exhausted by means of a steam-pump (Fig. 2).

This apparatus I have entered, taking with me a large India-rubber bag filled with oxygen. As the pump began to work, I experienced all the well-known symptoms of mountain-sickness, viz., quickening of respiration and pulse, which was considerably augmented by the least movement; sense of loathing, nausea, sensorial and intellectual perturbation. I felt indifferent to everything and incapable of action. On one occasion, having counted my pulse-beats for one-third of a minute, I tried to multiply the number of beats by three, but could not do it, and so was obliged to write on my bit of paper, "It is too difficult."

But all these symptoms disappeared as by enchantment so soon as I respired some of the oxygen in the bag; returning, however, when I again breathed the air of the cylinder.

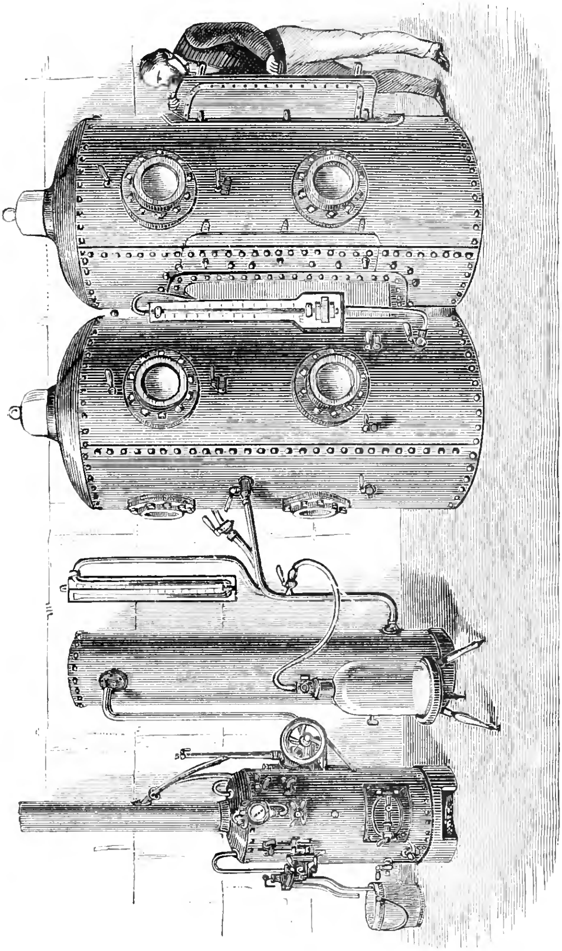


Fig. 2.

Fig. 3 gives the details of one of these experiments. In this figure the times of the different stages of the experiment are given at the foot: just above this is seen the curve which represents the rate of pulsation; and above this another curve, showing the barometric pressure in centimetres: the figures in the left-hand margin represent the changes of pressure and pulsation. It will be seen that, as the pressure is diminished, the pulse is accelerated. Thus, the pressure being 42 centimetres (answering to the elevation of Mont Blanc), the pulse-rate, which at the beginning of the experiment was 60, rose to 84.

At this moment I took two or three inhalations of oxygen, and at once the pulse fell to 71. Then I omitted the oxygen, and moved a little, when the pulse rose to 100, falling again to 70 when I returned to the oxygen. Ten times during an interval of one hour and twenty minutes, and with the pressure ranging between 40 and 50 centimetres, I at will produced these sudden oscillations, causing my pulse instant-

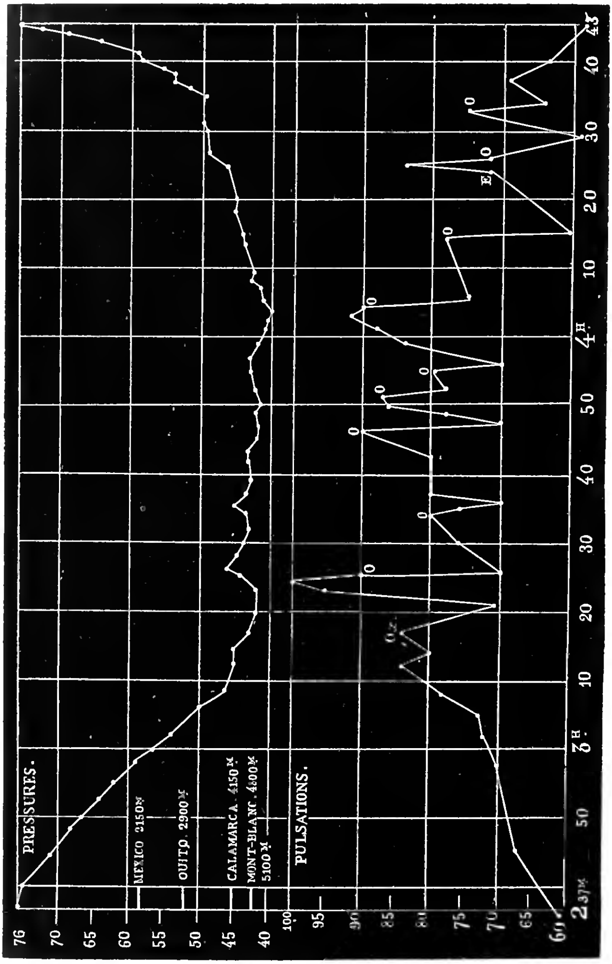


Fig. 3.

ly to rise or fall 20 beats. I may add that this is an experiment which I do not mean to repeat, having suffered during that evening slight congestive symptoms, which I attributed to these sudden changes of cerebral circulation.

On the other hand, those experiments in which oxygen is respired continuously are not followed by any injurious effects. Fig. 4 states

the results of that one of my experiments in which I reached the lowest degree of pressure. My pulse had grown more frequent, having risen from 60 to 85; the pressure was then only 40 centimetres. I now began to inhale oxygen from the bag, and at once the pulse fell to 65, at which point it stood during the remainder of the experiment, and at last even fell to 48. In the mean while the pressure had fallen to 246 millimetres. This is exactly the pressure on the highest

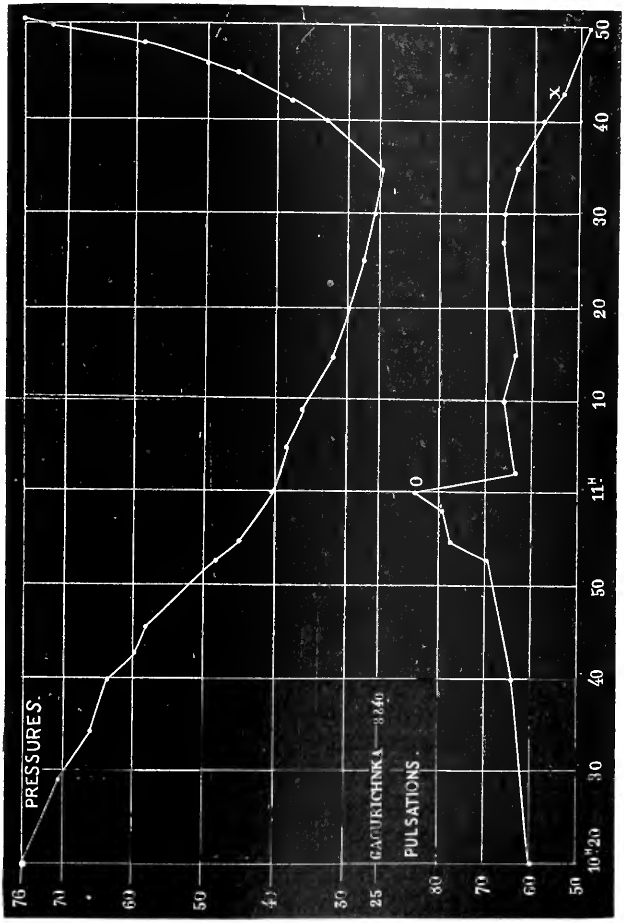


FIG. 4.

summit of the Himalaya—the same degree of pressure which was so near proving fatal to Glaisher and Coxwell; I reached this point without the slightest sense of discomfort, or, to speak more accurately, the unpleasant sensations I felt at the beginning had entirely disappeared. A bird in the cylinder with me was leaning on one side, and very sick. It was my wish to continue the experiment till the bird died, but the steam-pump, conspiring, as I suspect, with the people

who were watching me through glass peep-holes, would not work, and so I had to return to normal pressure. I placed, for a moment, the oxygen-tube under the beak of the bird, and at once he recovered.

Two other persons have, like myself, entered these cylinders, experiencing the same symptoms, and deriving the same benefit from the use of oxygen: these are Messrs. Crocé-Spinelli and Sivel. Crocé, who was very sensitive to reduced pressure, had turned black at the lips and on the ears, and could hardly see his paper, when he decided to have recourse to the oxygen. The effect was instantaneous, both upon him, who at once was able to write, and upon me, who observed with some anxiety the purple color of his ear, and was about to let in air.

Fresh from these experiments, Crocé-Spinelli and Sivel made their ascension of March 22, 1874, during which they rose to the height of 7,500 metres (a pressure of 30 centimetres). The faintness, the disordered vision, and the nausea, disappeared every time they "drank a little oxygen," as Sivel would say.

On the 15th of April, 1875, they made another ascension, in company with Gaston Tissandier. I was not then in Paris, and hence could not, as on the former occasion, superintend the making of the oxygen-bags. I would surely have made them larger, but probably I should no more than any of you have dreamed of what was the true cause of the catastrophe which followed. The oxygen-tube hung at a certain height above their heads, and, knowing that they had but very little of that gaseous cordial, they economized it against the moment when they should be more seriously attacked by sickness. But, when they wanted to take hold of the tube and to apply it to their mouths, their arms were paralyzed.

This terrible occurrence ought to be a lesson of prudence, but it must not serve as a pretext for discouragement. Crocé-Spinelli and Sivel died at 8,600 metres, with a pressure no greater than that reached by me without the slightest shadow of unfavorable symptoms, and it will be easy to devise measures which will insure the aëronaut against an attack of sudden paralysis. As for the value of ascensions to great heights, I am surprised to see it questioned by eminent men. What could be a more curious object of inquiry, from the point of view of the meteorologist, than that aërial zone, 10 or 12 kilometres in depth, in which are developed rain, hail, and snow storms? It is not wise to assign limits either to human activity or to the usefulness of scientific researches.

But to return to the theory of the symptoms produced by *decompression*. The experiments made in the cylinders demonstrate, beyond the possibility of doubt, that these symptoms depend solely on the tension of the oxygen in the air respired; an aëronaut breathing common air (21 per cent. oxygen) at one-half common atmospheric pressure is precisely in the same condition as a man who, at normal

pressure, breathes air that holds only one-half the normal proportion of oxygen. Consequently, he is subject to conditions of insufficient oxidation, and threatened with asphyxia. Hence his rapid respiration, in the effort to introduce into the blood the oxygen which is lacking; hence, too, the accelerated palpitation of the heart, and nervous and muscular debility.

But if the traveler whose blood is thus impoverished keeps perfectly still, he will not suffer much, for it needs very little oxygen to support the body in the state of immobility. But if he stirs about, if he tries to lift the weight of his body by climbing, then he has need of more oxygen than is contained in the blood; and, as this is not to be had, the symptoms of mountain-sickness make their appearance, and the only hope of relief is in repose. This is the reason why aëronauts, who perform no work, experience "balloon-sickness" at a far greater elevation than mountain-climbers experience the symptoms to which they are liable.

The cooler the air, the earlier the appearance of the symptoms. When it is warm, the traveler needs only a small quantity of oxygen to keep up the bodily temperature. But, when the air is cold, the loss of bodily heat increases, and hence the need of a more intense calorific oxygenation. But how can this be attained if the blood does not contain enough oxygen? This is the reason why, as I have already stated, mountain-sickness makes its appearance much earlier in the Alps than in the Himalaya.

Compressed Air.—For thirty years, physicians, following the footsteps of Junod, Pravaz, and Tabarié, have made use of compressed air in the treatment of sundry diseases, and they have produced remarkable results in cases of anæmia, passive hæmorrhage, chronic bronchitis, and emphysematous asthma. This I merely note in passing. Among the physiological phenomena, all observers have noted a diminution in the number of the heart-beats and of the respirations, and an increased amplitude of the latter. Physicians commonly employ a pressure of only one-third or one-half of an atmosphere, while I have specially studied pressures of several atmospheres.

These great pressures have been employed in various industries for a few years past, but more especially in submarine diving and in sinking piers for bridges.

In submarine diving, the diver incloses his head in a metal helmet with glass eye-pieces. Into this helmet, by means of a pump, compressed air is driven with force sufficient to expel it again through special orifices. Thus there is established an equality of pressure between the water around the diver and the air he breathes, and this is the *conditio sine qua non* of his being able to live beneath the water. Lead-weighted shoes and a water-proof dress complete the outfit. Messrs. Rouquayrol and Denayrouse have made the diver independent of the lighter or vessel from which, prior to their improve-

ments, he could not wander away, and this they have done by strapping upon his back a compressed-air receiver which works very ingeniously. Divers who fish in this way for coral, pearls, sponges, etc., descend to the depth of forty metres, and the air they breathe is under a pressure of five atmospheres.

The apparatus used in erecting bridge-piers is a great improvement on the old diving-bell. The discovery of the principle involved in these is due to M. Triger, who, in 1841, applied it to the construction of mine-galleries under the Loire. Nothing can be simpler than this principle: it is employed by children when they amuse themselves by blowing into a half-submerged tube, and causing the air to issue in bubbles. The apparatus, reduced to its simplest expression, may be described as follows: A tube of the length proposed for the pier is let down to the bottom of the river. It is capped with a chamber, into which is forced compressed air. This air expels the water from the lower end of the tube, and passes out just as in the child's play. The workmen can then, by means of a system of doors, as seen in Fig. 5, descend to the bottom, and there dig for the foundation of the pier. As the soil is removed, the tube descends by its own weight; it is lengthened by the addition of successive sections, till the solid rock is reached. The cylinder is now filled with *béton* and the pier is complete.

In these apparatus workmen have also been subjected to pressures as high as five atmospheres.

Now, both among divers and workmen in these tubes, symptoms have been noted often so serious as to terminate fatally. First there is an intolerable itching, called by the workmen "the fleas" (*puces*); then violent pains in the muscles and joints which have done most work; paralytic symptoms, particularly in the lower limbs, which often are persistent and fatal; finally, sudden death. Of 160 men employed on the foundations of the St. Louis (Missouri) Bridge, thirty were seriously attacked, and twelve died.

You are welcome to all the hypotheses invented by the fertile minds of physicians to explain these redoubtable troubles. Quite as a matter of course, we find here, first of all, the mechanical explanation: "When a man enters the tube," says one author, "he is *flattened out!*" (*aplati*). Very likely, indeed, if we admit that at the pressure of three atmospheres 4,500 kilometres more weighs upon our body. But, happily, we are saved from this fate by elementary physics.

The workmen in the tube at Kehl had a saying, as is usual among workmen everywhere; it is one full of acuteness and depth: "You pay when you leave." It is *decompression* and not compression that does the mischief.

But how does decompression act? Very simply indeed. Here in this glass jar is a rat subjected to ten atmospheres. I now turn a

cock, and in a moment bring the animal back to normal pressure; he turns around two or three times and drops dead. Were I to make an autopsy now, I should find the heart and the great vessels full of gas; so great is the amount, that once I drew off fifty cubic centimetres of

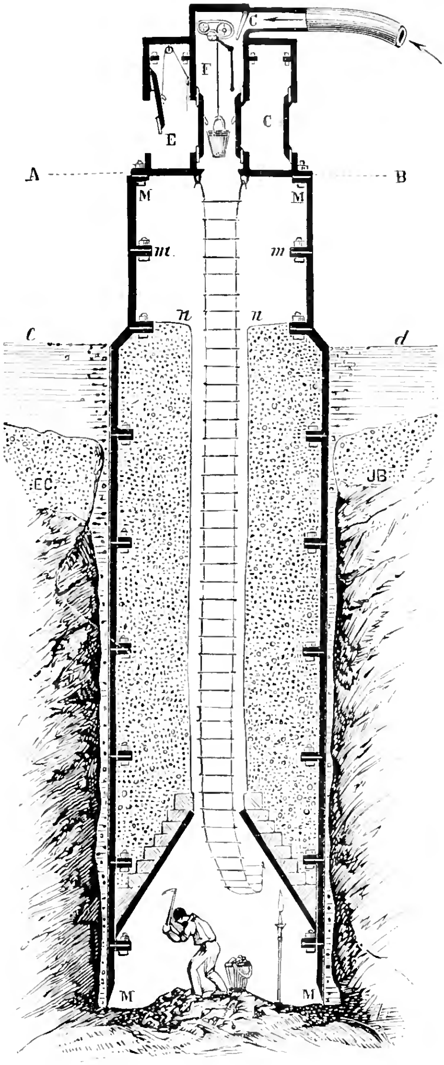


FIG. 5.

gas from the vessels of a cat *decompressed* in this way. This gas is nitrogen with a little carbonic acid.

The process is as follows: The animal by breathing compressed air charges its blood with air in the proportions indicated by physical

law; on the normal pressure being restord, the gases with which it was supersaturated pass into the free state. It is like drawing the cork of a bottle of beer. The oxygen combines on the spot, but the nitrogen is at once set free, and carries with it carbonic acid in becoming disengaged. Death is explained by the arrest of the circulation.

But it must not be supposed that the action of compressed air is harmless. If we subject a sparrow to a pressure of twenty atmospheres, it will, after a few minutes, be seized with tremors, increasing to most violent convulsions—convulsions stronger than those of tetanus or of strychnine-poisoning—and the bird soon dies. These terrible symptoms are not the result of compression, as I have been able to prove by two experiments. In the first place, they can be produced at the pressure of five atmospheres, provided pure oxygen be used instead of air, which latter has no special effect at this pressure. Secondly, they do not make their appearance if the air subjected to twenty atmospheres' pressure is very poor in oxygen.

Thus it is the oxygen that is to blame. Oxygen at too high a degree of tension destroys animal life. Long I hesitated to characterize as a poison the "nursing father" of everything that lives, but there was no help for it. Oxygen, which gives us life, slays also, when administered in too strong a dose. I have had to study thoroughly this paradoxal poison to determine the different effects of varying doses, and its action upon our tissues.

Here a new surprise awaited me. Having seen a sparrow killed by oxygen, I supposed that this agent must have accelerated organic combustion, thus consuming all the material which goes to maintain the animal heat. But great was my astonishment when the thermometer indicated in animals laboring under strong convulsions a fall of several degrees in the temperature. The analysis of other phenomena confirmed this first observation, and led me to the strange conclusion that oxygen in excess kills by interfering with, arresting, the intra-organic oxydation.

The effects of this powerful agent begin to be distinctly felt at the pressure of about five atmospheres. Perhaps they might be noticed at a lower pressure, and I am inclined to attribute to this cause the unfavorable symptoms presented by workmen who have spent several months in compressed air; but this is a complex problem. In any case, if the necessities of industry subject men to pressures higher than six atmospheres, they will be in danger not only at the instant of decompression, but even from the effects of the compression.

Oxygen at a high tension kills not only the higher animals: it acts alike on vertebrates and invertebrates, animals aërial and aquatic, plants and animals, big and little, even microscopic organisms. Its effects upon the latter are highly interesting.

From the admirable researches of Pasteur it appears that the phenomena of fermentation are of two kinds. One set of phenomena

are correlated with the development of microscopic organisms; this is fermentation proper. The other set are dependent upon the action of amorphous soluble substances; this is diastasic fermentation. Now, oxygen in a state of tension arrests the former class of phenomena, but in the latter class it is without any action.

Thus we can entirely prevent the fermentation of must, the souring of wine, the putrefaction of meat, etc., by means of oxygen in the state of tension. This work once done, we may restore the normal pressure, and then, provided germs from without are excluded, no true fermentation will occur.

I once hoped to be able in this way to preserve meats, eggs, etc., but this was an illusion. The substances do not become putrid, but, in consequence of a pseudo-fermentation, which sours them, they acquire a disagreeable taste, which takes from the process all its industrial value.

At the close of this long discourse I would call attention simply to one consideration. Atmospheric pressure acts a far more important part in the life-conditions of organisms than is commonly supposed. If we go back to the primordial geological ages, we may regard as highly probable the hypothesis that the pressure was then much higher than now. This must be taken into account when we investigate the origin of life. But, if we look to the future, it is plain that the pressure will go on steadily diminishing, just as the amount of water on the earth's surface diminishes; and hence all living things are doomed —after the lapse of countless ages, it is true—to perish by asphyxia from the lessening of the atmospheric pressure. Hence the limits of life upon the globe are fixed on the one hand by an excess, and on the other by a lack, of pressure.—*Revue Scientifique.*

HEAT AND MOTION, AND POLITICAL ECONOMY.

THE law of the mechanical equivalent of heat may be summed up in the following propositions, viz.:

The heat required in order to raise a given weight of water one centigrade degree of temperature can also lift the same weight 1,300 feet, or, more exactly, 424 metres. Thus to the unit of heat there corresponds a definite amount of work.

Conversely, a given amount of work produces also a definite amount of heat; in other words, there is required an amount of work equal to 1,300 foot-pounds, in order to raise the temperature of one pound of water one centigrade degree.

Heat and motion, therefore, are convertible.

Chemical processes are, in the last resort, the true sources of heat.

Here only a certain portion of the heat reappears in the shape of available mechanical work, the proportion for the steam-engine being one-twentieth of the heat produced by combustion of coal, and in the human body one-sixth of the heat developed by the conversion of the bodily constituents.

Every one knows what a revolution this law has brought about in physics and mechanics: it has added a new chapter to physiology.

There is only one science which, so far, has drawn no advantage from the discovery of the source of force and work, and that is no other than the very science of work, or political economy—in German, *Volkswirthschaftslehre.*

The grandest discovery in the doctrine of forces is as yet not even mentioned, far less turned to account, in a science whose object, nevertheless, is simply force—work.

But, then, this science is called *Wirthschaftslehre.* Surely no other name could so ill denote the thing as this, and I confess that I have always had an aversion against calling honest work by such a name. *Wirthschaftslehre* suggests ideas as remote as possible from economy—taverns and tavern-keeping. Far better is the Anglo-French term of political economy. If we must have a German name for the idea, let it be simply *Arbeitswissenschaft*—the science of work—for political economy, from first to last, has to do with nothing but human labor and its relations.[1]

But if we call this science no longer *Volkswirthschaft*, or political economy, but the science of labor, the very name will clearly show that it can rest on no other basis save the law of energy, of motion—the great law of the mechanical equivalent of heat. For work, including human work, is motion, and motion is heat. Of course, political economy does not touch on the laws of nutrition, the laws of food-substances or their transformation, for that is the province of chemistry and physiology. Political economy has to do only with the value of work, its price, and thence explains the phenomena of the market. Labor is the natural process whose social relations are known as political economy. The fundamental idea which political economy derives from labor is that of value. The production, the consumption, and the exchange of values (*Werthschaffung*, *Werthverbrauch*, *Werthtausch*), are the three principal divisions of the science of political economy.

In science there is no question that the value of a thing must express only the human labor expended on it. Price is the sum of the values that are given in order to move the will of the owner to renouncement of his right in the thing, his possession and his enjoyment of the work embodied in the thing. The idea of value requires deter-

[1] For the benefit of the reader who is not acquainted with German, it may be well to explain that in that language the ordinary meaning of the word *Wirth* is host, innkeeper; and of *Wirthschaft*, innkeeping, tavern, public-house.

mination of a value unit, for only thus can we know the value; or, to speak more exactly, only thus can we conceive the labor expended on the thing. We must be able to say, not only that labor has been expended on the thing, but also how much.

Marx was the first to essay the determination of a value-unit. This he found in a fixed term of "labor-time," usefully expended in the work. But time is no measure. The measure must be a *thing*, if it is to be cognizable at all, and such a measure is presented to us only in Mayer's law.

For, if work be equal to motion, and motion to heat, then a given amount of work (task) can also be regarded as equal to the amount of materials expended in producing the heat required for such work (motion). And hence, just as we compare a given net amount of effect from a steam-engine with the coal expended, so may we compare a certain amount of work with the amount of food expended in producing it; and since wheat contains all the essential elements of nutrition, we may compare a task with the quantity of wheat expended in performing it. Where a day's wages is paid in the shape of a day's provisions we have a crude example of the application of this theory.

Hence, as natural forces are gratuitous, the value of a thing expresses the amount of food expended in its production; and the value-unit is a fixed quantity of this food, say so much as is won by a day's work.

Exchange of values is effected with the aid of a thing in which are expressed the food-units required for its production; this is metal coin. Hence exchange-metal is both value and an index of value.

Mayer's law furthermore gives the law of wages. The workman must get back what he has expended in his labor in the shape of food; and this expenditure must be supposed to cover the cost of his bringing up and development, as also provision against old age when he can no longer work.

The idea of capital, too, and especially of the justification (*Berechtigung*) of capital, falls under Mayer's law. Experience teaches that the amount of food-material gained by labor is in excess of that expended in labor. This excess is capital in the strict sense, perfectly justified capital.

In virtue of the law of equal wages for equal work, every one, even though he does not produce (if we may so speak) food-stuffs, is entitled to the same surplus in recompense (food-stuffs) that he would have earned by work expended in the production of food-stuffs.

Perhaps it will be objected that Mayer's law applies to bodily labor, not to mental; but here, too, it holds good. The natural forces are gratuitous: it is only human labor that produces value. Now to natural forces belong not only the materials of the animal, vegetable, and mineral kingdoms, but also intellectual qualities, even genius itself.

Genius is a natural force which possesses a value only in so far as work has been expended in developing and applying it; this work produces values by consuming values.

All mental labor is at the same time brain-labor. The brain consumes a certain amount of food-material. Of course, all the other involuntary bodily movements which go on simultaneously with the brain-movements, as also the necessary periods of rest, must be taken into account in estimating the value of the products of mental labor.

Here, too, a definite amount of food-substances gives a definite quantity of (mental) work.—*Das Ausland.*

ON HEREDITY IN NERVOUS DISEASES.

By EUGÈNE DUPUY, M. D.

THE facts which I propose to consider in this paper have been brought to light by means of the experimental method. They are very interesting, both physiologically and psychologically viewed. I shall occupy myself with the physiological aspects only, and their bearing on human pathology. Psychology is beyond my province. Moreover, I conform myself to the saying of Montaigne, that deductions are very difficult to draw in psychological science, for "*comment cognoit on la semblance de ce de quoi on ne cognoit point l'essence?*" [1]

Most of the facts observed, of hereditary transmission of nervous disorders, were put on record many years ago by my eminent friend and teacher Dr. Brown-Séquard. Some I have observed, together with him, during the years that I was his assistant, and others I have discovered quite lately.

The disorders which were inherited had all been artificially induced in animals for the sake of experimentation. Very great care was taken in all cases to avoid causes of error, and I am positive that they were got rid of completely.

It will be seen that lesions which affect not only nutrition of parts, but also the higher functions of the nervous system, can be developed by hereditary tendencies, when artificially provoked, through those nerves which minister to organic functions—belonging to the so-called sympathetic system.

It is well known that a system of nerves exists in all animals which have a circulation, and which apparently has no other functions but to control the blood-vessels, to regulate the flow of the blood through them. This nervous system is called, therefore, the vaso-motor system; it is also termed the sympathetic.

[1] How can one know the like of that of which one knows not the essence?

It has been discovered that when a branch of that nervous system is sectioned, is separated from its centre, the blood-vessel with which it is connected almost at once enlarges: its calibre increases, more blood passes through it during a given time, etc. But if, now, this separated end of the nerve is irritated, the reverse phenomena are seen: the blood-vessel contracts, its calibre diminishes. When small arteries are experimented upon, the calibre becomes so small that blood-corpuscles no longer succeed in passing through it. So that it becomes evident that that nervous system has a great function to perform with regard to the nutrition of all the parts, or rather of every organ in the body, including, of course, the central, i. e., the spino-cerebral nervous system, for the "blood is the life of the anatomical elements." The materials which compose animal bodies are endowed with properties which differ in every different tissue: for instance, we say that the muscular tissue has the property of contracting. These properties of tissues develop functions: for example, the contraction of the ciliary muscle permits correct vision; but it is evident that if the tissue does not keep up the process of nutrition, i. e., assimilation and disassimilation, which it can only do by the agency of the blood which carries to it new materials, and removes effete elements, its properties are impaired and its functions are consequently perverted. This point being understood, I proceed to relate the experiments:

If in a Guinea-pig, for instance, that portion of the vaso-motor branch which is in connection with the carotid artery in the neck,—which, therefore, regulates the blood-supply of some part of the brain, of the ear, of the face, and of the eye—be divided, or, better still, if the ganglion from which that branch springs be removed, we see that the entire half of the head of the animal, on the side on which the operation has been performed, becomes hotter, and on examining more closely we discover that the increase of heat is due to the fact that the blood-vessels allow more blood to pass through them, that the nutrition of the parts is increased, and therefore the heat also increases; and we see that the upper eyelid of the animal drops a little, being in a state of hyperæmia—that is, its capillaries are distended—that the secretion of tears is increased so that the eye is wet, that the pupil of the eye is contracted because of more blood in the ciliary system, etc. The ear also becomes hotter, and, if the animal is white, we can see that the ear which before was white, with some blood-vessels stretching across, is now become red, and presents a very rich network of capillaries, which have become apparent, being of enlarged calibre.

Now, all these phenomena may disappear after a while, except a few. The eye always remains smaller, although the blood-supply of the eyelid is more regulated; the pupil remains a little contracted, and the secretion of tears continues, and also the nictitant membrane remains in a congested state. No matter how long the animal lives,

that state of the eye persists, and when the animal dies, or is sacrificed, it is seen that this eyeball is smaller than its fellow.

If, now, such an animal were allowed to breed with another—whether operated upon in the same manner or not—it would be seen that young which are born, apparently perfectly healthy, present a few days after birth all the phenomena observed in their changed parent or parents. They have the same smaller eyes, but on both sides; the same ear thickened and enlarged, etc. The only phenomena which they do not show are those which have been transient, the increased heat and the increased sensation which depended upon the increased amount of blood present, etc.

Those young can be made to breed in-and-in for several generations—I have watched them for five generations—and always the same characteristics will be discovered in the young.

If, now, an examination is made of the parent, the first one, it will be seen that the nerve which had been sectioned, or its ganglion which had been extirpated, is not regenerated; while, if an autopsy is made of one of the offspring of any of the subsequent generations, it is seen that they all possess the nerve and the ganglion intact. The acutest or most minute microscopic examinations do not discover any difference between their structure and those of other animals of the same family and species.

If a puncture be made into that portion of the upper part of the spinal cord which anatomists call the restiform body, in Guinea-pigs, it will be seen that the animal presents at once an increased vascularity of the ear on the corresponding side; the ear becomes gorged with blood, chiefly toward the periphery; sometimes in a very short time, indeed, that portion of the ear falls off, destroyed by dry gangrene. I have the record of a case in which the ear was thus partially destroyed in less than nine hours. The eye on the same side becomes larger and protrudes; it protrudes first, and becomes larger in the course of time.

If a pair of Guinea-pigs thus operated upon be allowed to breed, and even if only one parent is thus diseased, the other being healthy, when young are born, these young always present the phenomena observed in the parents; but the phenomena just described only come shortly after their birth. It is seen that their eyeballs increase in size and protrude from their sockets, their ears after a few days become diseased, just like those of the parents, the subjects of experimentation, and drop off, eaten by dry gangrene.

When the parent or parents are sacrificed, and their restiform bodies are examined microscopically, nothing is detected but a cicatrix in the envelopes of the spinal cord, which appear a little thickened at that point, but the nervous tissue itself does not differ apparently from surrounding elements of the same nature and structure. If an examination is also made of one of the young, nothing at all is discovered.

Those young can be allowed to breed in-and-in, and always the same phenomena will be observed in each subsequent generation. I have sometimes noticed that if a male or a female belonging to any one of the successive generations is allowed to breed with another healthy animal, very generally some of the young present the same hereditary peculiarities. I have followed animals thus operated upon through seven generations.

But what is still more remarkable is the transmission of an epileptic malady artificially induced. Dr. Brown-Séquard, as is well known, has for nearly thirty years made experiments on this subject of epilepsy, and his researches have discovered an array of facts of the highest value, to lighten the obscurity which has at all times rendered the true causes of that disease unattainable. He has made the like of what renders illustrious the names of the foster-fathers of experimental physiology—a synthesis: he has produced an epileptic malady in the Guinea-pig, which presents all the characteristics observed in that disease in the human species.

Dr. Brown-Séquard found that when the spinal cord of a Guinea-pig is pricked, or a portion of it is destroyed, or one of the sciatic nerves—that is, one of the largest nerves of the hind-leg—is either sectioned or torn off from the spinal cord, the animal in the course of a few weeks develops the epileptic malady. First, after a week or a little more, all traces of the operation have disappeared, as far as the wound is concerned. When the spinal cord has been operated upon, sometimes the feeling of pain is found lacking to a slight degree on the opposite side, and exaggerated below the point of the body at which the wound has been made; but most generally no such symptoms at all exist.

When the sciatic nerve has been cut or torn away, the greater portion of the leg is paralyzed as to motion and sensation, which is natural enough, because the muscles can no longer obey the mandates of the will, being deprived of the nerves which carry them, and also the centres no longer receive impressions which formerly came from those muscles and the skin covering them, because the nerves which carry the impressions have been destroyed.

It happens, also, in this case, that those parts which are thus deprived of motion and of sensation are dragged on the ground, are easily hurt, and become inflamed and enlarged. As soon as the skin has been broken, the animal begins to eat away all the parts of its leg which it does not feel; but it cautiously stops at the very limit where sensation still persists, so that, as, out of its three toes which terminate its posterior limb, the inner one is animated by nerves which do not come from the sciatic, that one toe has preserved sensation and motion. Therefore, when all the insensible tissues have disappeared, the wound heals very rapidly, and the animal has a limb which terminates by one toe only, the inner.

But another specially interesting fact with regard to epilepsy is this, that, a few days after the operation, whether made on the spinal cord or the sciatic nerve, it is found that an area of skin on the same side with the nerve destroyed or the spinal cord injured, which is limited by the line extending from the anterior extremity of the eye to the end of the nose, thence, comprising the upper lip, running along the neck to the shoulder, and then in a straight line to the posterior extremity of the ear, and, lastly, to the posterior angle of the eye, by degrees loses certain faculties and acquires new ones. The sensation of pressure, of squeezing, of heat, cold, or electricity, of pain in a word, all disappear; only the faculty of feeling tickling persists, and that appears exaggerated. In an experiment which I made some years ago, this effect followed within two hours of the operation on the upper spinal cord.

It is seen at the same time that tickling this zone gives rise at first to involuntary twitchings in the muscles of the jaw, of the eyes, and of the nose, on the same side; by degrees those twitchings become more strong and more general, then they manifest themselves on the other side also, and after a few weeks the animal has regular convulsions after each tickling of the zone, which lastly culminate in a regular attack of epilepsy, of which the features are the following: When the attack begins, the head is drawn first, and with great violence, at times toward one shoulder, at times toward the other. This has been explained by the contraction of the muscles of the neck. The mouth is drawn open by the same cause, and the muscles of the face and of the eyes, which had twitchings, now contract violently also. At this period it would appear that the muscles of the larynx are contracted to some extent. At all events, it appears that the vocal cords are contracted, for not unfrequently the animal utters an inarticulated, unnatural, sharp cry, which may be taken for the passage of air through the obstructed larynx. It then falls. The muscles of the legs are contracted stiff, those of the chest are thoroughly so; very soon all the muscles are the seat of convulsions. Respiration, which was in no little degree impeded during the time that the muscles of the chest were rigid, now becomes more frequent but very irregular. After a while the animal recovers, and remains in a state of stupidity for some time. It is not unfrequent to observe in these epileptic seizures fits of insanity—if I may use such a term when speaking of Guinea-pigs, but that word only will make my meaning understood. When these animals have been suffering for some months, it is seen that they have fits without apparent provocation; that is to say, spontaneously.

When they recover from the epileptic taint, all the phenomena observed about the zone of skin in the neck and face recur in the reverse order; that is to say, all the different sensations return by degrees, at the same time that the hair of that region falls, and new

hair grows gradually. The fits become simple convulsions, then mere twitchings, and lastly the animal can no longer be distinguished from another healthy one but by the fact that it has only one toe at one of its hind-legs, when the operation has been performed on the sciatic nerve; and nothing whatever remains when the origin of the disease was a prick in the spinal cord.

All these different facts, of which I have just spoken, are the characteristics of an epileptic seizure in our own species. That zone of skin about the neck and face is the analogue of those areas of the body of the epileptic from which sensations of all possible natures and kinds arise a short time before the attacks, and which are called by the general name of "aura."

To make the analogy greater, let me say that, just as in man, when such an "aura" is discovered to start from such a part of the body that it can be acted upon directly, so as to be removed, the disease is cured, so also, if that zone, of which I have spoken, in the Guinea-pig be cauterized, the fits do not occur—the animal is cured.

I have given these details with some minuteness, because they show still more strongly the effects of hereditary transmission of the disease. All the young of Guinea-pigs thus made the subject of experiment do not become epileptic; Dr. Brown-Séquard has observed several. I have had occasion to observe only a very few, and I have been able to learn that the young are born healthy, apparently. Sometimes—almost always, in fact—they are born with only one toe in the hind-leg; that is the case when the parent had lost its toes in the manner that I have already stated. Perhaps two months or more after their birth—they become adult very rapidly—the same phenomena develop in those young as in their parents; to use the words of Dr. Brown-Séquard himself, "we see the gradual increase of the affection, the diminution of the sensibility in the zone, just as with the parent, the coming of a period of complete attacks of epilepsy, and then the loss of hair, and the gradual diminution of the nervous complaint." Now, it is to be observed—and this is the important feature in this transmission of disease—that in the parent operated upon the cure, when it is spontaneous (that is, when it does occur without any treatment, which is the case when the sciatic nerve and not the spinal cord has been divided), only supervenes because the alteration in the nerve is cured: if it has been sectioned, the two ends meet again and are reunited after a few weeks; if it has been torn away, the parts still remaining attached to the outer heal together; we can therefore understand how, the cause of the disease, i. e., the alteration of a nerve, being removed, the disease, i. e., epilepsy, also disappears. But in the young which have inherited the taint no such explanation obtains. Their nerves have not been operated upon, not torn nor cut. How are we to explain their cure, and this fact, which is, as I have said, the peculiar feature of this

heredity, that the cure in the parent which has so characteristic stages should have exactly the same stages in the young as to circumstances and time?

I have said that I would only deal with this subject of heredity in its physiological aspects, but I cannot refrain from recalling to the attention of the reader that such facts in the human species need to be studied by psychological physicians, because they occur in insane patients, as is well known. Those alterations of the ears of which I have spoken at first are frequently met with in the ears of demented patients; physicians call them hæmatoma. I have satisfied myself that it is even more frequent than suspected in the inmates of asylums. That state of stupor, or stupidity, and of insanity, in the Guinea-pig, is of very frequent occurrence in the human epileptic. I could tell a long story of similar phenomena observed in our own species.

I believe that, if any conclusion can at present be drawn from those facts, a physiologist or a physician will state that it is not a disease which is inherited, which is transmitted, but the *power* to develop such a disease. On the one hand, a physiologist is bound to accept that the disease was originally developed as a *consequence* of an anatomical alteration of a certain organ or nerve-cell or fibre; and on the other he is bound to consider that the same disease or *consequence* develops itself in a young one which has no such circumstances of anatomical alteration of a certain organ or nerve-cell or fibre—at least detectable by any means of investigation at present employed.

This question of heredity is one of the most vexed, and I shall not say much more about it at present; but as I have stated that I am sure that there were no causes of error in the facts themselves or the deductions drawn from them, I take this opportunity to say that Mr. Galton has committed a grave error, in his very remarkable paper on "Heredity" published not very long ago, in which he stated that the Guinea-pigs which had epilepsy without alteration induced in their nervous system may have acquired the disease by imitation, just as, it is well known, is too frequently the case in the human species.

First, all the children or adults who happen to live with epileptic patients and witness their paroxysms *do not* develop epilepsy; only a very few do so. This fact would show, therefore, that those who do develop epilepsy have some tendency; but the argument of Mr. Galton does not hold good with regard to the first two series of facts which I have reported, and specially in the case of the Guinea-pigs which inherit epilepsy. How will he account, on the strength of his hypothesis, for the fact that, out of a couple of hundreds of young which were born from epileptic parents during the lapse of several winters in Dr. Brown-Séquard's laboratory in Paris, and which I have very studiously watched, only three became epileptic, although all lived together and all witnessed the fits of their parents, and only those three

developed the malady which were born toeless? I regret, on closing this paper, not to be able to take the psychological aspect of the question, because it is very interesting in a forensic point of view, and as bearing on the question of responsibility.

THE MATERIAL RESOURCES OF LIFE.[1]

By ALBERT B. PRESCOTT.

TO be able to live, in any way known to us, it is indispensable to have a body. And, as living bodies come by growth and continue by nourishment, it is first necessary to have materials whereof bodies can be made—and renewed and kept in warmth and strength. Just these materials, with permission of the reader, we will try to take account of, as resources of life. Life is not maintained "by bread alone;" other needful resources being known to physical science, and still other resources greater than all being recognized by their results in life; but we have the bread alone, as enough, certainly, to be considered in the present article.

Living things are in very deed made of "the dust of the earth;" but it is by no means all of the dust of the earth that serves this purpose. We have to distinguish between substances out of which organized instruments of life can be made, and a much larger number of substances never used in the making of these instruments.

We have it in mind that matter is made up of *sixty-three simples*. At all events, the earth's crust and air are constituted, substantially, of these sixty-three sorts of atoms, and, as a good many of the same are already revealed in the sun and stars by the spectroscope, it is likely that they are the chief elements in the universe of matter. Of the sixty-three, certain elements, found only in very small quantities, appear to be of subordinate importance in that part of the universe under our immediate observation, whatever purposes they may fulfill in other earths or in the centre of our own, or at other epochs. Others of the elements bear an important part in the structure of the globe or in the uses of mankind, but are not organizable materials, and they are not in our present consideration. Of the sixty-three, only *fourteen or fifteen simples*, about one-fourth of those known to us, are used in the construction of plants and animals. These, then, are before us, as the elemental resources of life.

It will be understood that the tissues are not built directly of these fourteen elements, but of *their chemical compounds*. Each one of these compounds is a definite substance in external character distinct from its constituents, as, in a familiar example, water is distinct from

[1] An address given before the Detroit Scientific Association, December 13, 1876.

the hydrogen and oxygen of which it is composed. The number of these chemical compounds built into living tissues is very great, a number uncounted. It is of these compound substances—of their molecules—that the cells are builded; builded by an action very unlike chemical action and into shapes very unlike chemical results. Also, it is by the consumption of these compounds of the fourteen elements that animal warmth and activity are sustained. But, not turning aside here to question the chemistry (the making of molecules) going on in cells, or the vital organization (the building together of molecules) going on in cells, not once lifting our eyes toward any of the dynamical sources of life, we bend our attention to find out, if we can, *the raw material for cells*, the inorganic resources of the organic world.

It is the organic world together, to be sure, that is able to subsist on the fourteen elements as these are given by the earth, the animal kingdom obtaining most of its material at second hand, as elaborated by the vegetable. The two kingdoms are, in the end, mutually dependent on each other in gaining sustenance from the earth's supplies.

The fourteen indispensable simples may be *classified*, in different ways for different ends. There is a privilege of provisional classification, for the sake of comparison and of acquaintance; and, with the promise not to impose our arrangement upon any other occasion, we would like, for the purposes of our present quest, to divide the elemental resources of life into two categories, as follows: 1. *Those supplied so abundantly on the earth that all individuals share them alike*, without favor of fortune or forethought of mind. We may name them redundant resources. 2. *Those provided so sparingly that individuals do not share them alike*, but secure them by effort and by opportunity. They may be termed adequate resources.

From the provision of the first class of materials, it results that, in certain great essentials of organization, all individuals are placed on a footing of equality with their fellows. It results from the provision of the second class of materials, that unequal qualities and quantities of organization are derived by different individuals of the same species. Through our redundant resources we are taught the common brotherhood of the created. Through our adequate resources come the assurances of our responsibility—our commissions as stewards of the earth. Materials given in a superabundance that cannot be wasted constitute a dispensation of mercy; its benefits falling alike on the just and on the unjust, the lazy and the diligent, the foolish and the prudent. Materials given in a competence that must be guarded constitute a dispensation of compensation; inciting to exertion, rewarding for attainment, and training the powers of volition. By the first, the democracy of equal privileges and inalienable possessions is maintained; by the second, the aristocracy of merit is preserved.

The redundant resources so abound that they can have no value,

in the sense of exchangeable value, in society; even though needed as they are in more constant supply than those of the other class. The resources which are barely adequate are those which come to be objects of personal possession; they are the things of which mine and thine are declared, and it is because of them that title-deeds are drawn and prices-current established. The substrata of poverty and of riches rest in the chemical elements.

With the definition of each class in mind, let us now consider the supply of some of the more important of the elemental resources. From the fourteen, let us take at least three elements of each class, as representatives. For the redundant resources, we will take carbon, oxygen, and hydrogen. Then, for the adequate resources, we will examine nitrogen, phosphorus, and potassium.

Carbon is the one element never left out of an organic compound. Its atoms are not only constituents, they are corner-stones of all the organic molecules. In the human body, thirteen parts in a hundred, or forty per cent. of the solids, are carbon. Looking for its supply, we see that it is obtained for the organic world by the plants, and from the carbonic-acid gas of the air. It is taken from the air chiefly by the leaf of the plant. How much carbon is taken from the organic mould of the soil and from acid carbonates, through the roots, is perhaps not fully settled; but we are well assured that the main and sure resource of the plant for this element is the air. The *supply*, then, is as abundant and impartial as the open air itself. The carbon-material forms but a small part of the air, it is true, only about five parts in 10,000; nevertheless, it is enough, at least for the average rate of vegetable nutrition. Carried around the globe in the viewless air to every plant alike, the carbon-atoms are supplied for the framework of every cell in plant and animal. A dwarfed shrub or rootless lichen, clinging to the crevices of a naked rock on a frigid shore, has at hand a good supply of the same resource that is furnished to a luxuriant palm spreading from a tropic soil.

And the carbon-supply in the air is not a reservoir diminishing, however slowly, from age to age; but, to be sure, it is a returning fountain, replenished from the exhalations of animals and the decomposing remains of all organized bodies. In Nature's economy, the same carbon-atoms are used over and over again as material for organization. This perpetual replenishment, a thrifty provision against future exhaustion, is one not peculiar to carbon, but it is a provision made in good degree for every one of the elemental resources of life, whether redundant or only adequate in its immediate supply.

That plants feed upon the carbonic acid of the air is known to the school-children, and has been known to men for a hundred and one years at least. Priestley, whose discoveries were celebrated in the chemical centennial at Northumberland, Pennsylvania, two years ago, placed it on record very clearly that "air vitiated by animal respiration is a pab-

ulum to vegetable life." This was but the next year after Priestley's discovery of oxygen itself; yet to this day there lingers in our common thought an undefined impression that the carbonic acid of the air is just an impurity, tolerated because there is only a little of it, but an impurity that it were as well to be rid of altogether. Now, if the redundant resources of life were at our human disposal, we might be in danger, some day, in the sheer forgetfulness of self-regard, of throwing away as an impurity the very foundations of sustenance. Some one, perhaps, would set forth that this gas when not diluted is immediately fatal to human life; another would declare, "Once a poison, always a poison;" and another would ask why we should imperil our own health for the sake of the plants.

Oxygen was named next, among the primary resources, redundant in supply. It is a prominent constituent of all living tissues, forming seventy-two parts in a hundred of the human body with its fluids. It is taken in two conditions: first, in combination, chiefly by the plants; second, in the elemental state, by animals. In combination, it is taken by the plants from carbonic-acid gas, just noticed as a source of carbon; from water, to be considered as a source of hydrogen; and, in smaller quantities, from a considerable number of other substances. The greater part of the oxygen in animal tissues is obtained in the products elaborated by the plants.

But for all animal life the most imperative demand is for oxygen in the elemental state.

The other elemental resources are available only in their compounds; oxygen does its best service when alone. The others serve life as materials for its bodily tissues; oxygen has an additional duty, the maintenance of operations giving warmth and strength. The activities of life consume various materials, but most constantly of all they demand a raw material of inorganic nature, a simple material in its primitive condition. This supply of *elemental oxygen*, a necessity for all animal life, is a necessity that is imminent in direct proportion to vital activity, and for man is absolutely imperative. When supplied with oxygen, we can subsist days without other food; when deprived of oxygen, life fails in a few minutes. It is scarcely a figure of speech to say that the breath is the life. The energy of oxygenation is told in every stroke of the heart. The food that is eaten does not raise an iota of bodily strength without the help of the pound and a quarter of pure oxygen that is daily inhaled. To breathe poorly is to faint; to eat richly and breathe poorly is to suffocate and perish.

The *supply* of elemental oxygen is certainly impartial and bountiful without reservation. It is more than given—it is pressed upon us; to escape from it is a work of toil and difficulty. No one is poor from want of it, or rich from gain of it. Were it furnished for pay, all that a man hath would he give for an hour's supply of it. The poor, taken together, fare best in its use; while the wealthy, in their elabo-

rate contrivances to exclude the cold and wet and wind and glare of the weather, can make but slight impediments to its distribution.

One other element we were to inquire of, among the redundant materials: the unit of chemical measures, *hydrogen.* As light as it is, it makes over nine weights in a hundred of the body of man. It is obtained chiefly by the plants; mostly from water, but to some extent from ammonia, the latter being more notable as a source of another element.

Water is not quite always as free as air—failing the needs of the stationary bodies of plants more often than it does the wants of animals, and in the quantities taken as food by man hardly liable to a notable value in exchange. As a substance not wholly gaseous, it is not easy to conceive how water could be more abundantly supplied than it is, without being a burden and a hinderance to life. It is doubtful whether mankind would vote for any uniform increase in the quantity of water on the planet. If water was supplied in vapor more abundantly than it is, by having a lower vaporizing-point, the conditions of all life would be changed—the atmosphere would be put out of its adjustment with the organic creations.

Some of the simpler forms of life subsist almost wholly upon the three elemental materials we have had in consideration, with a few others of the plentiful resources; and living beings taken together use much larger quantities of these than of the substances more sparingly supplied. But, as to the relative importance of the two classes of resources, it can only be said that the higher forms of life can no more exist without the one than without the other.

Of the adequate resources, *nitrogen* is needed by the largest number of living bodies and used in the largest quantities. It enters into most animal tissues and the more complex of the vegetable products; being two and a half parts in a hundred of the body of man, or eight per cent. of its solids. It is obtained for the organic world solely by the plants, and obtained only from combinations of nitrogen, the ammonia and nitrates of the air and the soil.

The *supply* of this combined or available nitrogen in the air is limited—enough for a measure of vegetation, but not near enough for the greatest growth of food-plants and grains. The quantity of combined nitrogen carried by the rain from the air to the plant-roots was found to be, in the rainfall of a year in Great Britain, equal to seven pounds of ammonia on an acre; another year it equaled nine and a half pounds per acre. The constituents of wheat are such that twenty-four bushels require the nitrogen of forty-five pounds of ammonia; that is, for the crop on a given surface, about five times as much as the rain furnishes. Plants doubtless gather directly from the nitrogen compounds of the air without help of the rain, and obtain a larger supply from the organic mould of good soils; but that all these sources together provide hardly enough is pretty clearly

proved by feeding the roots of the plant with additional nitrogen compounds. On all but the richest soils, the suitable application of ammonia or nitrates causes a notable increase in the quantity of food-plants, and also causes an increased proportion of the nitrogenous constituents of plants. If nitrogen compounds could be laid down cheaply enough, it would augment the supplies of food and raiment, and the comfort of man, in no small degree.

Right here it comes to mind that uncombined nitrogen forms over three-fourths of the weight of the air—a provision of about eleven pounds on every horizontal square inch—and a question rises, "Why cannot the vital forces take hold on the pure element and use freely from its most lavish supply?" Well, because the universe exists. The stomach does not digest the carbon of charcoal; nor do the lungs take oxygen from water. To propose any alteration in the character of one of the sixty-three elements is to undertake the reconstruction of the universe. It is the character of nitrogen to refuse chemical combinations. Uncombined nitrogen is nowhere available for vital uses, to any appreciable extent. Filling perfectly its humble service in Nature as a diluent in the air, its qualification is to be inert and to remain changeless. Among the resources of life and in the marts of subsistence where its compounds rank high in value, nitrogen as a simple has no place at all.

This barrier between nitrogen and its compounds seems to hold firm from age to age. Out of the ocean of atmospheric nitrogen the plant selects the scattering molecules of nitrogen compounds and elaborates therefrom many nitrogenous substances. The animal elaborates some of these into other compounds. But in the final decay of products and tissues, and food not assimilated, the nitrogen of all returns again to ammonia—again in the aërial ocean, and again the resource of plants. If ammonia is oxidized in the air to nitric acid, the latter is deoxidized in the soil to nitrous acid and then to ammonia. All these compounds are very frail, and change most constantly, but together they hold the little stock of united nitrogen, losing little of it and gaining little for it, from epoch to epoch.

There are leakages, to and fro through this remarkable barrier, it is true, but they are so small that little is known of them, except that they show the strength of the barrier that limits them. On the one side, there is a little loss, by the liberation of traces of nitrogen in certain organic decompositions. Also, the explosive agents used by man in warfare and the arts result in the liberation of nitrogen—an expenditure of life-resources. On the other side, by the electrical disturbances of the atmosphere, traces of nitrogen are brought into union. The roll of thunder indicates the restoration of a modicum of that good material which was wasted for the roll of artillery. Again, it is believed that in organic decay under restricted conditions some measure of nitrogen is brought into union with nascent hydrogen.

Chemical art has not done anything toward the appropriation of this obstinate element. Nothing nitrogenous can be made of nitrogen. The manufacturers depend on gatherings from the sparingly distributed nitrates of the earth. As machinists have dreamed of perpetual motion, sleeping chemists may dream of an invention to bring atmospheric nitrogen into use, that all the barren places may be made fertile, and the whole earth flourish as a garden of fatness. But for this dream to realize the proportions of a fair probability it is quite essential that chemistry should be well asleep.

The chief commodities bearing nitrogen are nitre or saltpetre (potassium or sodium nitrate), and ammonia. In Hindostan, the rich soil-mould, warm and alkaline, becomes thinly crusted with nitrate, which is gathered and brought to market as East India nitre. Gunpowder, gun-cotton, and nitro-glycerine, as well as chemical products, are made with it. In the War of 1812, America was thrown upon her own sources for gunpowder-material, and enough nitre was found in the cave-deposits of the Southwestern States. Then France was hemmed in by hostile armies, and had neither nitre nor cave-deposits, but it was after the work of "Lavoisier of immortal memory," and the government put trust in chemistry. Berthollet and the rest soon justified the trust in the perfection of the "nitre-plantations"—beds of farm-refuse with wood-ashes exposed to the air.

These products, soil-nitre and compost-nitre, and the ammonia obtained as a by-product in the manufacture of illuminating gas, serve their several purposes in the arts and applications of man, but their limited quantities do not warrant their addition to the soil for the increased growth of food. Now, unlike these common supplies, the earth possesses a special resource for nitrogen in combination, anomalous in being fully mineralized and remarkable in being both concentrated and extensive, a chain of mines full of nitre. On the Pacific coast of South America, extending from the fourth to the fortieth degree of south latitude, about 2,400 miles along the slope of the Andes to the sea, in Bolivia, Peru, and part of Chili, there has been found a line of deposits of sodium nitrate, the "Peruvian nitre." The beds are of variable thickness, covered by one to ten yards' depth of earth and half-formed sandstone. The dry soil of the most of this rainless country is pervaded, in some degree, with this deposit. The mummied remains of the old Peruvian people are embalmed with it by the earth in which they were buried; and its crystals glisten on those ghastly relicts which were presented in the Peruvian department of the Centennial Exhibition, and those brought to this country by Dr. Steere. It has been estimated that in the province of Tarapaca, within fifty square leagues, the quantity of the nitre is not less than 63,000,000 tons. The appropriation of this vast resource has been taken up rather slowly, but has much increased for ten or twelve years past. Vessels laden with it go to the coasts of manu-

facturing countries. At Glasgow the works devoted to the production of ordinary saltpetre from the nitre of Peru extend over acres of ground. In 1868, 100,000,000 pounds were used in Great Britain. As yet, it has been applied to the nourishment of crops only to a limited extent. But this seems to be its chief destination, and for this use it lies in the earth, a vast mine of wealth, for the disposal of coming generations. When multiplied population puts the sustaining power of the earth really to the test, this fund of sustenance on the Peruvian coast must come to outweigh in value the gold and silver mines of the Californian coast.

Of the several nitrogen compounds which nourish plants, ammonia yields the most immediately satisfactory results. And, of this fertilizing material, some wellnigh mineralized deposits must be counted in with the earth's possessions. To take note of these ammoniacal materials, we have again to begin at Peru. Standing on the shores which front the nitre-beds, and looking westward upon the Pacific, there are seen, as we are told, the low patches of the Cincha Islands —islands which shine with the whiteness of a powdery covering, a loose deposit of considerable depth. A cargo of this substance was first taken to London in 1840, stored and advertised for sale, and after a while thrown into the Thames. A second cargo was tried as a fertilizer by an English farmer, and found to give such marvelous results that the shipping company made good haste to contract with the Peruvian Government for the entire deposit. This article, well known as guano, has held a settled value ever since its introduction, and, had it come into the hands of the alchemists, it would, very likely, have been presented as an elixir of vegetable life. Now, its worth is graded by analysis, and is indicated chiefly by the proportion of ammonia it contains.

The absence of rain will account, perhaps correctly, for the unusual retention of the soluble material characteristic of the guano of Peru; but the *formation of the nitre-beds* of that region is a problem in geological chemistry more difficult to determine. There are evidences of volcanic overflow and of marine deposition, and the alkali in the compound may have originated in either of these or other sources, but neither the volcano nor the sea could furnish the nitrogen of the compound. If not from organic accumulations, we seem to be referred to the air as the source of nitrogen, and left to conjecture the conditions and forces which could bring elemental nitrogen into union in so great a quantity. Without pursuing these inquiries, it may be permitted to cite a fact which seems entitled to consideration in the case, namely, the conditions for an unusual overflow of atmospheric ammonia in this region. It is fed by perpetual trade-winds—winds coming from the southeast across a wide continent of soil that is rich to rankness, and warmed under a vertical sun. Coming from the Atlantic and saturated with water, these winds gather the exhalations

of a continent, and then, shedding their water on the Andes, leave their ammonia (it may be supposed) to find its way by some means to the valleys of the western slope.

Again, these same mountain-valleys of Peru may claim to have given the world still another token of unexampled sources of nourishment, in the growth of the *cinchona-tree*, bearing the richest stock of nitrogenous bases in the vegetable world. It seems, indeed, more than a coincidence that this narrow, rainless, wind-nurtured slope of land should send to all the earth three such eminent resources as Peruvian nitre, Peruvian guano, and Peruvian bark.

Another of the materials adequate for no more than the needs of life is *phosphorus*. This element so far differs from nitrogen that it is not found uncombined in Nature, and if separated by art it immediately enters into combination on exposure to the air. It occurs chiefly as phosphate of lime, taken from the mineral kingdom by plants and also by animals. The hard part of bone is about nine-tenths phosphate, and phosphorus is an element of molecules organized into muscle and nerve.

The proportion of phosphates in the crust of the earth below organic remains is very slight, insufficient for the support of the higher forms of vegetable or animal life. It has been concentrated and gathered into the soil by the selective agency of the organic world, as it continues to be concentrated from the soil by each individual plant, and from vegetable products by each individual animal. Nearly all the phosphorus accessible on the planet has been a constituent of living bodies. Its proportion in the soil is a main factor in the growth of cereal grains. Already, and with the stretch of land to the westward, bone-earth and phosphatic guanos are well known in American markets. When phosphates fail at the root of the plant, grain fails at the mill; and when, from waste at the mill, phosphates fail in the bread, the bones and the teeth fail in growing bodies. The improvidence that leaves excretory phosphates to be washed away to the salt sea, farther from the reach of life than they were in the primitive rocks, is an improvidence that prepares an inheritance of poverty for after-generations. And the ruthlessness that permits the purveyors of food to sift phosphates from the food of men does its part to enfeeble the present generation.

There remains to notice another representative of the adequate resources, *potassium*. The statements made as to the supply of phosphorus, with some reservation, become true for potassium. Certain of the rocks contain a proportion of it, but from insolubility this is slowly available, and is insufficient for the needs of higher organic life. The soils contain more, because the organic world has gleaned for the soil. Potassa and soda are two alkalies which replace each other in the laboratory at the convenience of the chemist, but, in the choosing of the living cell, one of these is always taken and the other left.

We get potassa free from soda in the ash of a tree which grew in a soil having more soda than potassa. From sea-water, containing near 200 parts of soda to one of potassa, the sea-weeds furnish an ash having two to twenty times more potassa than soda. From the blood of man, having ten to fifteen times more soda than potassa, the muscles obtain a composition of six or seven times more potassa than soda.

This gleaning is good proof of the value of more, and the evidence is confirmed by the application of potassa as a fertilizer. The stock of potassa—which is used somewhat in the arts—is derived mainly from the gatherings of the organic world. The ash-wagon takes up the savings of the hearth. In France the washings of sheep's-wool are saved, and 160 pounds of good potassium carbonate are obtained from a ton of the wool. In the pioneer life of this country, the housewives have burned corn-cobs and taken the ash for baking-powder, eighty per cent. potassium carbonate, and preferable to the "dietetic saleratus" now used. Should the ash of the entire corn-crops of the United States be taken without loss, it is estimated that over 100,000,000 pounds of potassium carbonate would be obtained. In the salt-beds of Stassfurt, Germany, there is a good proportion of potassa, and the use of this supply has been steadily increasing, both as material in manufactures and as a fertilizer.

At the present time, the market value of the resources of life engages little general attention. There is a narrow branch of commerce, wherein the prices-current of the three elemental materials which we have taken as "adequate resources" are the values constantly under calculation in daily business. In this guild, one sells nitrogen at thirty cents, another offers phosphoric acid at five cents; and all parties have a tacit understanding that the values of nitrogen, phosphoric acid, and potassa, are to each other about as six, one and a half, and one, and that these are the only values to be considered. The technical terms of any profession or pursuit are jargon to the general ear. But hearing a man say that he "sold a hundred tons of rectified Peruvian at thirty-one cents for nitrogen, this morning," it is not so much as understood in what sort of business such jargon belongs.

Thinking of the multiplication of life and the waste of its resources, it seems that, in the time coming, the phrases that tell the rise and fall of value in commercial fertilizers may find some general recognition—may even have as much meaning for everybody as the terms of the gold-market and the silver-stocks.

It is only about a hundred years since man began to attain such definite knowledge of the components of matter as enables him to trace (we by no means say to understand) the transmutations of earth and air into tissues fit for life. Thirty-six years ago, Liebig commenced giving the people the first really systematic lessons upon the

material resources of life. Seeing the value of a knowledge that goes below the surface of things, in 1852 he wrote his conviction that, "ere long, a knowledge of the principal truth of chemistry will be expected in the political economist and statesman, as it already is held indispensable to the manufacturer and physician." And, seeing the meanings and the mysteries that cluster around the primary forms of matter, he wrote at another time: "It is not the mere practical utility of these truths which is of importance. Their influence upon mental culture is most beneficial; and the views acquired by knowledge of them enable the mind to trace, in the phenomena of Nature, proofs of an infinite wisdom—for the unfathomable depths of which language has no expression."

THE ZODIACAL LIGHT.[1]

By Professor C. E. BRAME, A. M.

THE purpose of this contribution is to draw attention to a phenomenon which has received too little notice, and has been strangely neglected by astronomers, but which, in fact, if the conclusions of the author of the work under review are correct, is to the inhabitants of the earth one which emanates from a very near and remarkable cosmical body.

The third volume of "The United States Japan Expedition" records a series of observations on the zodiacal light, which were made by Rev. George Jones, A. M., chaplain in the United States Navy, from April 2, 1853, to April 22, 1855, during which time he accompanied that expedition sent out by the United States Government, under the command of Commodore M. C. Perry. It also contains the observations and theories of other astronomers, particularly those made by the celebrated Dominicus Cassini, a distinguished *savant* of the seventeenth century, attached to the Royal Observatory at Paris, who was the greatest cosmologist of that age.

The deductions of our author are—1. That the zodiacal light is emitted by a nebulous ring, with the earth for its centre; that is, there is a ring of nebulous matter around the earth; 2. That 60° is the full width of the stronger light, and 90° its full width including the diffused light; 3. That it is on both sides of the ecliptic; 4. That it may be seen in some latitudes under favorable circumstances, forming a continuous arch across the heavens; 5. That it must rotate on a com-

[1] Third volume, United States Japan Expedition. "Observations on the Zodiacal Light from April 2, 1853, to April 22, 1855; made chiefly on board the United States Steam-frigate Mississippi, during her Cruise in the Eastern Seas and her Voyage homeward; with Conclusions from the Data thus obtained." By Rev. George Jones, A. M., Chaplain, U. S. Navy.

mon centre, and seems full of commotion within itself; 6. From observations made then and afterward at Quito, in South America, that it is not entirely dependent on light reflected from the sun, but must shine partly by its own light.

These conclusions are given to the public with much diffidence, and with strong arguments to support them, based on a large accumulation of facts ascertained by the most careful observation.

Our chaplain became intensely interested in this investigation, and has recorded three hundred and twenty-eight observations on stereotyped star-charts, published with the volume. Sometimes, when unable from sickness to go upon deck, he was carried in his cot, that he might have an opportunity of noticing this intensely interesting phenomenon. As the voyage was one which circumnavigated the globe, he had a most favorable opportunity to prosecute his examination; and his recorded statement embraces a most minute and faithful account of his observations in nearly every longitude, and over a tract extending from 41° 49′ north to 53° 48′ south latitude.

After the return of the expedition he sought the earliest occasion to go to Quito, in South America, which is directly on the equator, where he saw the light extending in one continuous arch across the heavens. During his residence there he published several articles in *Silliman's Journal* on "The Zodiacal Light," which gave additional interest to the subject.

If anything since then of importance has appeared in any scientific journal on this subject, we have not met with it. Having for over twenty years considered it, and being anxious that more information and more confirmed conclusions should be arrived at concerning it, we invite the attention of the learned and observing to the consideration of this subject. We believe that there is no physical truth which stands isolated, but every new discovery in physical science opens the way for other truths and discoveries. If naturalists can spend days and weeks in examining and commenting on a new discovery in botany or zoölogy; if foreign countries are visited, forests and mountains traversed, to bring to light some hitherto unknown plant; if it is a triumph for a naturalist to discover a new species of microscopic animalcula—surely it is not time wasted to direct attention to a cosmical body so interesting as the zodiacal light.

Astronomical science is full of attractive interest to every lover of Nature. It is not astonishing that the study of the heavens is the oldest natural science. At an early period of the world's history the human eye and intellect were directed, with absorbing interest, to the azure arch above us, amid whose vast expanse orbs of grandeur are unceasingly running their wonderful courses. The stars, beaming with inextinguishable brilliancy, are known to be oceans of flames and centres of worlds, though apparently but points of light. The planets were known to the ancients to be more identified with our world than

other stellar bodies. Traversing space with inestimable velocity and performing their revolutions with unvaried regularity, they have long been known as part of our solar system. It seems strange that a cosmical body so near the earth as the zodiacal light should have received comparatively so little attention.

As many who read this article have never seen this light, it is necessary that it be described.

It is defined, in the work under review, to be "a brightness that appears in the western sky after sunset, and in the east before sunrise; following nearly or quite the line of the ecliptic in the heavens, and stretching upward to various elevations according to the season of the year." There is a slight objection to this definition, by which inexperienced observers may be led astray. It is spoken of as appearing after sunset, by which some would be led to suppose that it is visible immediately after sunset; whereas it is never to be seen until after the night has fully set in, and the sun's rays are some distance below the horizon. Its varied elevation, indeed its appearance, is also dependent upon the latitude of the observer as well as the season, so much so, that in very high latitudes it is but seldom seen to advantage. It has also been seen at almost every hour of the night, but is usually more distinctly seen in the temperate zones, when observed between dark and nine o'clock, as after that hour its light frequently becomes dim and diffuse.

> "It appears to best advantage when the ecliptic makes its highest angle with the spectator's horizon, at which time, in moderate latitudes, it reaches to the zenith or beyond it, having near the horizon a striking brilliancy, and thence fading upward, mostly by imperceptible degrees, till at its vertex it can be made out only by a careful and experienced eye. As the seasons advance, when the ecliptic is declining gradually toward the horizon, the zodiacal light fades away till it is perhaps entirely lost to view, or can be seen only by those who have followed it in its changes, night after night, and are thus able, by familiar acquaintance, to detect and trace its dim markings in the sky."

Humboldt, in "The Cosmos," vol. i., remarks:

> "Those who have been for many years in the zone of palms must retain a pleasing impression of the mild radiance with which the zodiacal light, shooting pyramidically upward, illumines a part of the uniform length of tropical nights. I have seen it shine with an intensity of light equal to the milky-way in Sagittarius, and that not only in the rare and dry atmosphere of the summit of the Andes, at an elevation of from 13,000 to 15,000 feet, but even on the boundless grassy plains, the llanos of Venezuela, and on the sea-shore beneath the ever-clear sky of Cumana."

Prof. Olmsted, in his "Astronomy," describes it as follows:

> "Its form is that of a luminous pyramid, having its base toward the sun. It reaches to an immense distance from the sun, sometimes even beyond the orbit of the earth. It is brighter in the parts nearest the sun than in those that are more remote, and terminates in an obtuse apex, its light fading away by insen-

sible gradations until it becomes too feeble for distinct vision. Its aspects vary very much with the season of the year."

The crepuscles, or streaks of light from the sun, must not be mistaken for the zodiacal light; the former are sometimes visible between twilight and dark, the latter not until the shades of night have fully set in. Neither must the milky-way be mistaken for it by inexperienced observers, as the zodiacal light has a warm yellowish tinge unlike the cold white light of the milky-way.

Having endeavored to open the way for a consideration of the subject, we will now proceed to give a history of former observations.

There is no mention of any appearance of this light by very early writers. There is mention of Arcturus and the bands of Orion in the book of Job, and the constellations of the zodiac were assigned names at a very early date. The zodiacal belt was in use among the ancient Egyptians and Hindoos. If this light had been visible, it is highly probable some ancient writer would have spoken of it. Our author observes:

"It is scarcely probable that a phenomenon so striking in southern latitudes should have escaped the attention of early astronomers in those countries, but we meet with nothing in their works (referring to it) of a fully definite and reliable character."

He is, however, of the opinion that it may have been overlooked or mistaken for the crepuscle at early dawn or twilight.

It has been supposed that Pliny, who wrote in the first century of the Christian era, alludes to it under the name of *trabes* or the δοκους of the Greeks, but Humboldt thinks that Pliny refers to another matter.

Ammonius, in his life of Charlemagne, A. D. 807, mentions an appearance somewhat like the zodiacal light, but there was no reliable notice of it before it was described in Childrey's "Britannia Baconica" in 1661, which gives a brief description of its appearance and shape. The reference to it may be found in that work, at page 183.

It was reserved for Cassini to direct attention to its examination for the first time with earnest inquiry and interest. His first notice of it was on the evening of the 18th of March, 1683. He was watching in the west for other things, but was struck with the appearance of this luminous streak reaching far up in the sky. Like most discoverers, Cassini immediately formed a theory in regard to it after making but ten observations. This hypothesis, based on very insufficient data, has continued to the present time to influence the opinions of astronomers, and has retarded interest in observing its phenomena. Like most theories of the heavenly bodies in their first origin, it was doubtless erroneous, and, like the Ptolemaic theory of the solar system, it has materially interfered with the establishment of a correct knowledge of what is the truth.

Cassini discovered very soon that as time advanced through March and April, the upper or northern edge of this light inclined more and more from the ecliptic, and stretched farther to the northward; and knowing that the sun's equator, as shown by his spots, was also then stretching off from the ecliptic in a similar way, he came to the conclusion that the substance giving this light was closely connected with the sun's equator, and was consequently changing its position with regard to that equator.

He argued, further, that as the sun has an atmosphere, and is therefore capable of emitting dense vapors, and is continually sending out matter of exceeding fineness which we call light, consequently this luminary might also, by its motion on its axis, send out a substance intermediate in character between the two; which substance, either self-luminous or by reflection, might give us the zodiacal light. To support this theory, he gives to this body a lenticular shape, about twice the thickness of the sun as seen in March, but only of the sun's thickness when seen in June. Whether he meant to have this lenticular-shaped medium to be attached to the sun, and revolving with it at the same time, is not apparent. He devoted a part of his time for about eleven years, in a very desultory manner, to observing this light.

Cassini's labors led other observers to direct their attention to the zodiacal light. Fabio de Duillier, who was his colleague for a while at Paris, is worthy of particular notice, as having conceived the idea that it consisted of particles of matter distinct from the sun, and arranged in shape like a solid zodiac; which body of uneven surfaces, and rotating round the sun, he supposed, gave us the zodiacal light.

In 1731 Mairan gave considerable attention to this subject in a work on "The Aurora Borealis." He advanced the theory that this light is reflected from the sun's atmosphere, stretched out into a flattened spheroid or lenticular-shaped body, revolving with the sun—an idea which Laplace has forever set at rest by demonstrating that the sun's atmosphere can extend no farther than to the orbit of a planet whose periodical revolution is performed in the same time as the sun's rotary motion about its axis, or in twenty-five days and a half; that is, only so far as nine-twentieths of Mercury's distance from the sun.

Since the time of Mairan, until 1853, but little attention appears to have been given to this subject. In 1833, however, Biot, in order to account for the meteor-shower of that year, attempted to show that the shower was owing to the earth's passing at that time near the node of the zodiacal light. But calculations were made by J. C. Honsseau in order to see whether the nodes of the sun and the zodiacal light do actually correspond. After careful observations and calculations, in which he was assisted by nine diligent observers, Housseau thinks he has shown that these nodes are different, and that

therefore "the supposition of the existence of this light in the plane of the sun's equator does not satisfy the observations made." The closing sentence of his very interesting article gives the first intimation that the zodiacal light has a near connection with our globe. Housseau says:

> "One is struck, without doubt, with the near approach, which our elements show, between the line of nodes of the zodiacal light and that of the nodes of the terrestrial equator upon the ecliptic. This circumstance, as far as it is verified, may help to explain the causes of this luminous phenomenon—causes which are, it may be, more local than has hitherto been supposed."

This notice is the only one, of any importance whatever, that was taken of the zodiacal light for many years, with the exception of some experiments made to ascertain whether there is any heat connected with it—experiments which we think resulted in establishing the fact that it is near enough to emit heat sufficient to affect a thermo-electric pile of twenty-five pairs, causing the needle of the galvanometer to indicate 12° when the pile was directed toward the base of the zodiacal light.

We come now to a consideration of the observations taken during the cruise of the Japan Expedition, and we hope our readers are not weary of the subject; for, if it can be demonstrated that we have a ring of nebulous matter around our globe at a distance of 150,000 to 200,000 miles, there are many inquiries growing out of that fact full of interest, and yet to be answered by experiment and induction. It will be a matter, then, to be considered whether it is self-luminous—that is, of the nature of the sun's photosphere—or whether it shines only by reflected light, like the rings of Saturn; whether it is increasing or diminishing in magnitude and extent. If it is shown to be self-luminous, we will then wish to know whether it may not be widening and extending itself, at the same time increasing in its capacity to emit both light and heat, until it envelops the entire globe, modifies climate, melts the icebergs and snows of northern latitudes, and dispels darkness from our globe. We may inquire, too, whether it may not be used as a grand instrument in the hands of the Creator for the future development of his purposes in regard to our globe. It may also be an inquiry whether it does not already influence the magnetic state of the earth, and play an important part in the causes producing the aurora borealis. These and many more similar questions will arise from the establishment of the fact that the zodiacal light emanates from a ring of nebulous matter so near our earth. Let us, then, give our author a close examination and a patient hearing, that we may be enabled to form a correct judgment as to the truth of his deductions.

We have not space to present all the reasoning by which our author shows that the zodiacal light cannot be produced by a ring of nebu-

lous matter revolving round the sun, either within or beyond the orbit of the earth.

He starts with the proposition that such a ring must be either—1. Within the earth's orbit; 2. Surrounding the earth; or, 3. Without the orbit of the earth.

It cannot be *within* the earth's orbit; if so, we could never have it at any great altitude at any period of the night, and we could never have the zodiacal light at midnight on both horizons simultaneously.

We omit the diagram constructed for the consideration of the theory which supposes this ring to be around the sun and *beyond the orbit of the earth*, by which he shows that this supposition will not account for the lateral changes observed in the zodiacal light. He says:

> "The query arises, 'Can such lateral changes, so uniformly observed, as the evening or morning advances, agree at all with the idea of a nebulous ring giving us this light at a distance from the spectator of 160,000,000 or 180,000,000 miles?' A ring of the character supposed, it seems to me, could give us a zodiacal light only of one uniform shape, namely, with the opposite borders receding from each other for a short distance from the apex, and then running parallel, one to the other, the whole way down to the base. Nor could the hourly changes of time produce any other changes in these boundaries than a rising or sinking of the apex of the light; the boundaries, say at nine o'clock P. M., extending a little higher in the sky than at eight, and so continued, with a parallelism of the opposite sides, down to the horizon. How different this from the true facts of the case!
>
> "The evident and most decided connection between these boundary-lines and the spectator's place, as regards the ecliptic, is also a matter of the greatest significance in drawing our conclusions in regard to the origin of this light. Now, supposing the base of the zodiacal light to be at a distance of 200,000,000 miles, how is it possible that the fact that the spectator is a short distance north or south of the ecliptic can govern the reflection from the nebulous ring at that immense distance, and place it on his side of the ecliptic? If he is on the north side of the ecliptic, not only is the main body of the light down to its base on that side, but the lateral changes of the boundaries, as the hours pass, are altogether or chiefly on that side; and so equally with the south. If he is on the ecliptic or near it, the zodiacal light stretches equally, or nearly so, on each side of that line. Also, if he changes rapidly during the night to or from the ecliptic (as was the case on shipboard) the boundaries of this light also change, being regulated by his motion (from one place to another). That the apex of the zodiacal light, from such a ring around the sun, might be so affected by the spectator's position is not unreasonable, but that the boundary-lines should be so affected seems to be utterly inadmissible.
>
> "It is worthy of remark, also, how even and uniform, from apex to base, the change in the boundary-lines is as the hours change; as if the substance giving the zodiacal light were not only near, but also at one uniform distance from the spectator; the portions of it at the apex and base of the light all equally affected by his changes on the earth."

He shows by Bouguer's law of reflected light that the zodiacal light, if from a ring of nebulous matter beyond the earth's orbit,

would emit a light of the same intensity the whole way from the base to the apex. But another law of optics, that the strength of light is inversely as the squares of the distances of the object affording the light, would here make its application; and this ring, at our zenith, being by that supposition about 140,000,000 miles nearer to us than at the base, we should then have the zodiacal light far more intense at the apex than at the base; all of which is entirely opposite to the facts of the case.

He offers, now, as a last conclusion, *the hypothesis of a nebulous ring with the earth for a centre.* He makes certain deductions from the examination of the preceding theories.

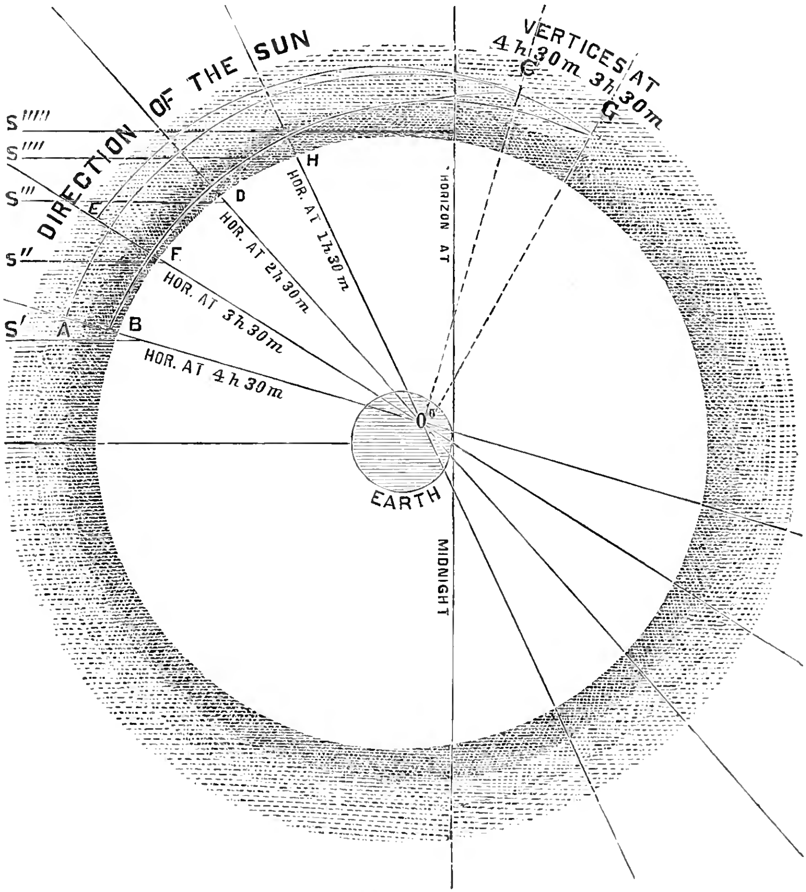
> "They are—1. That the substance giving us the zodiacal light must be *equally near* to us in all its parts, inasmuch as the lateral changes of the light, i. e., the changes of boundaries, have a uniform character and mostly a parallelism in their whole extent from apex to base; 2. That no part of this substance can be very remote from us, inasmuch as the outlines of the light were clearly and sensibly affected by my own position on the globe, and even by my change of position in a single night; and, 3. That the laws of reflected light require an arrangement or a shape of this nebulous matter which will give us, at the base of the zodiacal light, larger angles between the lines of the incident and reflected light than at other portions, and also a regular decrease of such angles from the base to the apex of the light, as produced by such a shape. These three requirements appear to be fully met by an hypothesis which, if the theories examined are untenable, is now the only one remaining to us.
>
> "The hypothesis is that the zodiacal light is *a ring around the earth.*
>
> "The thought is a somewhat startling one, yet startling only from its novelty; for it is entirely in accordance with what we know of our sister planet (Saturn), and also with the whole of Laplace's celebrated theory of the formation of globes."

We will not take up time and space with quoting his application of that theory in explaining some of the phenomena of this light.

Avoiding the consideration of these topics, we will proceed to apply the result of Bouguer's experiments on reflected light to this case.

In the annexed diagram he takes an observation made on the 4th of September, 1854, as an example, for the reason that it is a simple one, and one also in which the spectator is near the plane of the ecliptic. It was made in latitude 22° 18′ north, longitude 114° 10′ east. The sun rose at $5^h\ 48^m$. The stronger light was at $3^h\ 30^m$ to $4^h\ 30^m$, the diffuse light at $3^h\ 45^m$. Sun's longitude 161° 35′. The horizons at $4^h\ 30^m$, $3^h\ 30^m$, $2^h\ 30^m$, and $1^h\ 30^m$, and at midnight, are given, together with the line of the spectator's vertices, as well as his positions O, o, etc., at $4^h\ 30^m$ and $3^h\ 30^m$. A, B, C, F, are the boundaries of the zodiacal light at $4^h\ 30^m$, and E, F, G, at $3^h\ 30^m$; the apices C and G are carried a little above the more condensed portions of the ring; but the reader is at liberty to suppose them to be at any other part, as he may think best. The direction of the sun is given; and S′, S″, S‴, S⁗, S′⁗, are supposed to be rays of light proceeding from that luminary.

In this diagram, the sun's rays being S′, S″, etc., BO, FO, etc., will be the reflected rays; and the several angles between these lines of incidence and reflection, together with the number of rays reflected



Nebulous Ring, with the Earth for its Centre.

[The relative proportions of the earth and the ring, and also its distance, are of course not given in this diagram with any effort at certainty; the upward extent of the ring is probably far greater than can be here represented. The diagram is, however, sufficiently correct for our present purposes of elucidation.]

to the eye, out of every 1,000 incident rays, according to Bouguer, are in the following table:

ANGLE.		Rays reflected from Smooth Water.	Rays reflected from Plate-glass not quick-silvered.
S′, BO	161°	343	422
S″, FO	146°	184	270
S‴, DO	131°	101	162
S⁗, HO	116°	59	105
S′′′′′, at midnight	90°	18	25
S′′′′′, CO	67°	18	25

"We find in the above table a strong argument for such a ring around the earth. The figures, taking either of the two columns, for water or for glass, correspond in a very striking degree with the varying intensity of the zodiacal light from the base upward, as we have it on any clear morning or evening when the ecliptic is at a high angle with the horizon, and when, consequently, the nebulous figure is not brought angularly to our eye. They also correspond to what is, indeed, almost synonymous with what has been stated—namely, to the fact that at $4^h\ 30^m$ the zodiacal light at the horizon is far greater at its base than it is at $3^h\ 30^m$; at $3^h\ 30^m$ than it is at $2^h\ 30^m$, etc., back to midnight. Any person who has ever looked attentively at this light when making a high angle with the horizon will see at once the coincidence between the proportions of the figures in the above table, showing the number of reflected rays, and what has been always presented to the eye. If the reader will also carry these lines of incident and reflected light beyond the midnight horizon-line, to any point there of the nebulous ring, he will see how we may easily get what is referred to in my charts under the German name of *Gegenschein*, i. e., dim light seen, when the circumstances are favorable for it, in those portions of the sky opposed to the sun. This hypothesis shows also very clearly how I could have the zodiacal light above both horizons at the midnight hours, as I was often able to do, and it harmonizes fully with the strength of the light as then presented to the eye. While there are some things still left unexplained, I have yet not been able to see anything in this hypothesis antagonistic to the facts of the zodiacal light. On the contrary, almost all of them are explained by it; and they all, as I can perceive, fully harmonize with it through the whole of the manifold change which the light underwent, either from the changes of the ecliptic toward any fixed point, or from my numerous and great changes of latitude during our cruise.

"If we could have a zodiacal light of an undoubted character produced by the *full moon*, not only would the question before us be set at rest, but the ring would be shown to be within the orbit of the moon, and how near we came to a case of the kind on the evening of February 14, 1854, the reader will decide for himself. . . .

"This ring must, according to the laws of matter, rotate on its centre; and it must be full of commotion within itself. The existence of *pulsations* seems scarcely to admit of a doubt, recorded as they have been by observers in such distant quarters of the globe."

In conclusion, we would say that two simultaneous observations, made in equatorial regions—for instance, one by an observer at Quito, and another by an observer on the island of Sumatra, in which both observations presented the zodiacal light stretching as an arch across the heavens from east to west—would, it seems to us, demonstrate the fact that it is a ring around the earth. Now, if observations taken in almost every space of 15° of longitude have been made and its existence demonstrated, does not that amount to about the same thing?

We leave the subject, inviting information and discussion from all who are informed in regard to this long-neglected phenomenon.

DR. BALFOUR STEWART.

AMONG English physicists Dr. BALFOUR STEWART holds a distinguished place for the originality and extent of his experimental researches, the grasp of his subtile and comprehensive inquiries, and the boldness and freedom of many of his speculations.

He was the son of a merchant, and was born in Edinburgh, November 1, 1828. At the age of fourteen he went to the University of St. Andrews, and afterward to that of Edinburgh, from which he graduated. During his college course he paid a great deal of attention to pure mathematics, and is credited with having rediscovered, independently of books, La Grange's method of dealing with the differential calculus. After leaving college he spent four years in a mercantile house, and was for two or three years in Australia; but his father's preference that he should be a merchant did not coincide with his own inclinations, and he at length determined to devote his life to physical science.

On his return from Australia, he was so fortunate as to secure the friendship of the late Principal Forbes, and became his assistant in Edinburgh for three years, 1856–'57–'58.

Dr. Stewart has been Director of the Magnetic Observatory at Kew, where he has made numerous and important magnetical observations in connection with the eminent physicist, Mr. Warren De la Rue. He is Professor of Physics in Owens College, Manchester, a Fellow of the Royal Society of Great Britain, of the Astronomical and Meteorological Societies of London, and of various learned bodies on the Continent and in the United States. He received the degree of LL. D. from Edinburgh University, and in 1868 the Rumford Medal of the Royal Society for his researches in light and heat.

Dr. Stewart has been a very active worker in the scientific field, and is the author of many publications, especially in the branches of meteorology, magnetism, and solar physics, of which the following are the most important:

Papers connected with Heat and Light.—1. An Account of Some Experiments on Radiant Heat, involving an Extension of Prevost's Theory of Exchanges (Transactions of Royal Society, Edinburgh, 1858). 2. Researches on Radiant Heat, Second Series (Transactions of Royal Society, Edinburgh, 1859). 3. On the Light radiated by Heated Bodies (Proceedings of Royal Society, London, 1860). 4. On the Nature of the Light emitted by Heated Tourmaline (Proceedings of Royal Society, London, 1860). 5. Internal Radiation in Uniaxal Crystals (Proceedings of Royal Society, London, 1861). 6. Report on the Theory of Exchanges (British Association, 1862).

Papers connected with Meteorology, Magnetism, and Sun-spots.

—1. On an Instrument for measuring Fluctuations of Temperature (Proceedings of Royal Society, London, 1856). 2. Reduction of Makerstown Magnetical and Meteorological Observations, from 1847 to 1855 (Transactions of Royal Society, Edinburgh, 1860). 3. On the Magnetical Survey of Scotland undertaken by the late Mr. Welsh (Report of British Association, 1859). 4. An Account of the Self-recording Magnetographs erected at the Kew Observatory by the late Mr. Welsh (Report of British Association, 1859). 5. On the Great Magnetic Disturbance, August to September, 1859 (Transactions of Royal Society, London, 1861). 6. On the Nature of the Forces concerned in producing the Greater Magnetic Disturbances (Transactions of Royal Society, London, 1862). 7. A Comparison of the Kew Curves with the Earth-Currents registered at Greenwich during the Magnetic Storm of December 14, 1862 (Proceedings of Royal Society, London, 1863). 8. On Earth-Currents during Magnetic Calms, and their Connection with Magnetic Changes (Transactions of Royal Society, Edinburgh, 1863). 9. An Account of Some Experiments with an Air-Thermometer (Transactions of Royal Society, London, 1863). 10. Results of a Comparison of Simultaneous Traces of Self-recording Magnetographs at Kew and Lisbon—in conjunction with Senhor Capello (Proceedings of Royal Society, London, 1864). 11. On the Sudden Squalls of October 30 and November 21, 1863 (Proceedings of Royal Society, London, 1863). 12. Note on the Secular Change of Magnetic Dip at the Kew Observatory (Proceedings of Royal Society, London, 1866). 13. A Description of the Self-recording Instruments of the Meteorological Committee (Report of the Meteorological Committee for 1867). 14. A Comparison between the Records of the Barographs at Oxford and Kew (Proceedings of Royal Society, London, 1867). 15. An Account of Experiments on Aneroid Barometers (Proceedings of Royal Society, London, 1868). 16. On the Laws regulating Magnetic Peaks and Hollows (Proceedings of Royal Society, London, 1869). 17. Results of a Preliminary Comparison of the Kew and Stonyhurst Declination Curves—in conjunction with the Rev. W. Sedgreaves (Proceedings of Royal Society, London, 1869). 18. Remarks on Meteorological Reductions (British Association, 1869). 19. Results of Observations of Dip and Horizontal Force made at Kew from April, 1863, to April, 1869 (Proceedings of Royal Society, London, 1870). 20. On the Variations of the Daily Range of Atmospheric Temperature as recorded at the Kew Observatory (Proceedings of Royal Society, London, February, 1877). In this paper the author shows that in the daily range of temperature there is unmistakable reference to the moon. 21. On the Variations of the Daily Range of Magnetic Declination, as recorded at the Kew Observatory (Proceedings of Royal Society, London, 1877). In this paper Prof. Stewart establishes the opinions previously held by Mr. De la Rue, Mr. Loewy, and himself, clearly showing that in the variations of declination range at Kew

there are inequalities having reference to planetary configurations. He also shows that there is a great likeness between meteorological and magnetical phenomena, and suggests that a further study of sun-spots may ultimately enable us to predict longer and longer meteorological occurrences.

Papers on the Heating of a Disk by Rapid Rotation in Vacuo.—1. On the Heating of a Disk by Rotation in Vacuo—in conjunction with Prof. Tait (Proceedings of Royal Society, London, 1865). 2. On the same subject—in conjunction with Prof. Tait (Proceedings of Royal Society, London, 1866). 3. On the same subject—in conjunction with Prof. Tait (Proceedings of Royal Society, London, 1873). 4. (A Possible Explanation of its Effect?) On the Temperature Equilibrium of an Inclosure containing a Body in Visible Motion (Literary and Philosophical Society, Manchester, November, 1870). Dr. Stewart endeavors to explain the heating of a disk of rotation *in vacuo* by an extension of the theory of exchanges.

Papers on Solar Physics by Messrs. Warren De la Rue, B. Stewart, and B. Loewy (Preliminary Researches—printed for private circulation by Mr. De la Rue).—*First Series:* On the Nature of Sun-spots (1865). *Second Series:* Area Measurements of Carrington Observatory, and Deductions therefrom (1866). *Third Series:* On the Distribution of Spots in Heliographic Latitude.

Kew Researches.—1. Heliographic Positions and Areas of Sun-spots observed with the Photoheliograph during the Years 1862 and 1863 (Transactions of Royal Society, London, 1869). 2. Positions and Areas of Sun-spots observed at Kew during the Three Years 1864–'66, as well as Fortnightly Values of Spotted Solar Area from 1832 to 1868 (Transactions of Royal Society, London, 1870). 3. On Some Recent Researches in Solar Physics, and a Law regulating the Time of Duration of the Sun-spot Period (Proceedings of Royal Society, London, 1871). 4. Further Investigations on Planetary Influence upon Solar Activity (Proceedings of Royal Society, London, 1872). 5. On a Tendency observed in Sun-spots to change alternately from the one Solar Hemisphere to the other (Proceedings of Royal Society, London, 1873).

Besides various miscellaneous papers, not mentioned here, Dr. Stewart is the author of the following works:

An Elementary Treatise on Heat; Lessons in Elementary Physics; Conservation of Energy ("International Scientific Series"); and The Unseen Universe (in conjunction with Prof. Tait).

CORRESPONDENCE.

MIND-READING BY THE EAR.

To the Editor of the Popular Science Monthly.

SINCE the publication of my article on "Physiology of Mind-Reading," in the February number of your MONTHLY, I have received the following, which, as presenting a new phase of the subject, is of much interest.

There are three general methods of mind-reading—by the touch, by the eye, and by the ear. My article was devoted only to the method and modifications of the method introduced by Brown—by the touch. Mind-reading by the eye—that is, watching the movements and changes of the features, or of the hand or fingers—is done every day by all of us, and is frequently utilized with great success by mediums. Mind-reading by the *ear*, as described in the first experiment noted in the following letter, is not so well known. The author of the letter, who does not wish to have his name used, is also an expert in the art of mind-reading by the eye or by the touch.

The general physiological principle is the same in all these methods of mind-reading—namely, the detecting by the operator, through some one of the senses, of the unconscious muscular or bodily movements of the subject, through mind acting on body. GEORGE M. BEARD, M. D.

Dr. George M. Beard—

DEAR SIR: I was much interested in your article on the "Physiology of Mind-Reading," as I have paid more or less attention to the subject, in an amateur way, for eight or ten years past, and I think that I can give you some new "developments."

While your theory is undoubtedly correct, you describe certain conditions as "essential" which I have found by frequent successful practice to be unnecessary. Thus you say that the connection between the subject or subjects must be such "as easily to allow the sense of muscular tension to be communicated." The operator or medium "must be in physical connection with the subject." Again, "where the connection of the operator with the subject is made by a wire, so arranged that mass-motion cannot be communicated, . . . the operator does just what he would do by pure chance and no more." In reply to this, I would say that I am in the habit of repeating Brown's tricks of finding hidden objects, designating persons and things thought of, etc., without any physical contact whatever, while I am blindfolded, precisely as Brown was in his public performances.

The only condition I require of the subject is, that he shall follow me at a distance of about three or four feet, as I grope my way *apparently* at random, keeping his mind fixed upon the object. I am able to tell, by close attention, when he follows me readily, and when reluctantly; in this way I cautiously map out the *direction* in which he tends to follow me most readily. When I approach the vicinity of the object thought of, he shows no inclination to move in any one direction. There is, of course, a certain element of uncertainty in the finding of a small object under these circumstances, but the proportion of failures is astonishingly small. I reached this result by a succession of experiments, first through a rigid rod, then through a wire, then a stretched string, then a string with a loop. I then worked without contact *not* blindfolded. I would walk backward, holding out my right forefinger, and directing the "subject" to hold his right forefinger, at a distance of six inches (this would convey to most people the impression of two terminal poles of a battery or electrical machine), and he would often have an imaginary pricking, as of sparks at the finger-tip. I would then proceed around the room, and when moving in the right direction the hiatus would be rapidly closed between the two fingers.

I can almost invariably distinguish an intentional or accidental indication from an involuntary one, and I do not find that keeping the "arm perfectly stiff" interferes very seriously. The indications are not confined to muscular contractions or relaxations of the arm, but it is a sympathetic movement of the whole body.

It is a curious fact that subjects who naturally work well will be very slightly influenced by the explanation of the apparent mystery. You may assure them that every *correct* movement you make is only a translation of their own, and they will declare positively that they are trying to move in the *opposite* direction, and, in fact, they often do hold back with their feet, while giving the most positive indications with their arms.

I have found that a large majority of well-educated people have an innate bias for mysteries, and prefer to refer these "phenomena" to animal magnetism, auras, psychic or odic force, or any incompre-

hensible cause, rather than to the rational explanation of unconscious movement. Some time since, I had a curious illustration of this fact, and at the same time an admirable proof of the physical theory (if any were required), in an experiment suggested by a gentleman of this city. I had concluded a successful exhibition at an evening company, and described the precise method by which the experiments had been performed. This gentleman said to me privately that he could suggest an experiment which, if successful, would disprove my theory of muscular or physical movement. I retired from the room, and was brought in blindfolded. Meanwhile he had requested a very good subject with whom I had done a number of complicated things to hide an article. The gentleman then took the towel from *my* head and blindfolded the "subject"—turned him rapidly round several times, and told him to think of the object. He said, "Now you will find it by mental communication only." I started off rapidly, but, of course, received no indications. I then purposely touched his hand to the mantel-piece in the back-parlor. Instantly he unconsciously calculated the position of the hidden article and directed (not led, for I always go in advance of the "subject") me toward the front-room; then he was lost, until I again touched his hand to some object, when I received a fresh indication. In this way I finally found a ten-cent note, rolled into a little ball, and attached to the lower knot of a cord running through the handle of a small feather-duster, which was hanging from the bell-handle on the wall. I did not, however, immediately produce it, as I wished to experiment further. I led the "subject" off to another part of the room, and he immediately brought me back to the duster. Again I led him away to the same place, and turned him round so as to confuse him. All indications ceased, even when I held his hand within an inch of the duster.

In regard to finding small objects, I have no difficulty in picking out any letter on a page of a book or newspaper, and I frequently spell out abstract thoughts or names of people, places, etc., thought of, in this way: I hold a sharp-pointed stick or pen-handle in my left hand, pointing downward, with the same hand grasping the left hand of the "subject." I thus pick out letters on the page which spell the thought in the mind of the "subject."

The power of perception of these minute indications is capable of being developed to an astonishing degree, and I have often been amazed at the curious effects produced, a few of which I have indicated to you.

To the Editor of the Popular Science Monthly.

In Tyndall's discourse on "Fermentation and its Bearings on the Phenomena of Disease," as published in the December number of The Popular Science Monthly, he describes an injury he met with in falling upon some sharp rocks. He limped to his hotel, and remained quietly in bed for four or five days, and, having quite recovered, removed the bandages, and found the wound "perfectly clean, uninflamed, and entirely free from pus." This slight exposure led to inflammation, an accumulation of pus, and, finally, to an abscess several inches below the wound, and might have led to fatal results. A year after, Tyndall exposed in the same room tubes containing organic infusions, and in two days the infusions were swarming with the bacteria of putrefaction with which the dust-laden atmosphere was charged.

I have lately been reading General Hazen's interesting book entitled "The School and the Army," and in it find the following testimony regarding the treatment of wounds in in-door and out-door hospitals, which, taken in connection with Dr. Canniff's correspondence in the April number of your magazine concerning Dr. Lister's antiseptic treatment of wounds, may be of interest to your readers. General Hazen says:

"The Germans have fallen into the same error that we committed—that of using buildings for hospitals instead of tents, or field-hospitals; and there is scarcely a doubt that the French will do likewise. It is unaccountable that scientific and practical medical men do not appreciate and advocate the advantages of out-door over in-door hospitals. It is a matter of the gravest importance, and the humane societies of Christendom can in no way do more good than by thoroughly investigating and making generally known the facts relating to permanent hospitals in time of war. The seeds of disease cling to the walls, ceilings, and floors, and the death-rate of the wounded is often greatly increased by putting them in these places. So strongly was I impressed with this in our war that, as far as was in my power, I kept my wounded out of them. At the battle of Mission Ridge, the colonel of the Forty-first Ohio lost his leg above the knee by a musket-shot. I forbade his going to hospital, and caused him to be treated in his rude, split-shingle cabin, and his recovery was remarkably rapid. Officers of my command who were grazed by musket-shot upon the arms were put into the hospital, and died from gangrene. At that battle the wounded of General Thomas's army were treated in fixed hospitals, or buildings fitted up beforehand at Chattanooga, with many comforts and good care. The proportion of deaths among the wounded was frightful; and we were told that it was due to the low

vital condition of our men, resulting from short rations. The fact was, they died from hospital diseases. General Sherman's army, just arrived from Mississippi, without hospitals, treated their wounded in the field, and the proportion of recoveries was astonishingly great. They were cured by fresh air. At the battle of Peach-Tree Creek, a very worthy staff-officer of mine was seriously, although not dangerously, wounded in the abdomen. The medical rules were very strict, but, by sending messengers all night, I got authority to send him home to the North, without his going to the hospital. Arriving at Nashville, and being unable to proceed without further medical authority, he was taken charge of, and put into one of their comfortable hospitals. In a few days he became terribly afflicted with gangrene, and only escaped with his life after a perilous and racking illness."

These observations are doubtless familiar to surgeons; but if, with Tyndall's experiments, they are found to be absolutely correct, does it not become necessary to examine into the condition of the various hospitals throughout the country, and to provide at least some special conditions for the treatment of flesh-wounds — an apartment, for example, separated from the main building, which may be deluged at intervals with superheated steam to destroy the germs, or such other precaution as shall insure an atmosphere of absolute purity during the dressing of wounds?

We would commend this subject to the State Boards of Health.

EDWARD S. MORSE.

SALEM, MASSACHUSETTS, *April* 26, 1877.

THE NEW IDEAS ABOUT SPACE.

To the Editor of the Popular Science Monthly.

THE great attention now given to this subject in Europe seems to render appropriate a short communication to bring it more directly before Americans. In point of fact, the mathematicians have been making a conquering migration into the fair fields of philosophy, and instead of any longer being content to receive from Metaphysics her definitions of space, they have for themselves attacked the question by the methods furnished by two thousand years of advance in their own science. Already they have made some wonderful strides toward the solution, and the new notions are very fascinating.

It is, perhaps, daring to attempt to give an adequate idea of some of these without the use of mathematical symbols and analytic geometry; still it seems desirable for each of the special sciences to be able to express *results* in untechnical language, and we will try.

Every schoolboy knows that what is called multiplying a linear inch by a linear inch gives a square inch, and that again multiplying this square inch by a linear inch gives a cubic inch. Now, I suppose, many of the most original boys may have asked themselves, "What would be the result of multiplying this cubic inch again by a linear inch?" Up to this nineteenth century the answer has probably always been, that the thing was unthinkable and inexpressible, and that, although by analogy we see no reason for being stopped so abruptly, yet such is our invariable experience.

Now, the two men who first and independently stepped over this mental fence were the great Gauss whom Germany is now celebrating, and a Russian named Lobatchewsky. They both said that the space with which we are familiar is only one kind of space out of a number of possible spaces, each logically self-consistent; but that, from the fact of all our ages of experience being in this particular space, we cannot perfectly picture to ourselves any one of the other kinds, though they are entirely expressible in analytic geometry.

Now, it has often been remarked that in things very familiar to us we see nothing noteworthy. So we see nothing strange in our conception of a straight line and a plane, yet we may think it strange when we are told that this peculiar notion of straightness, smoothness, or flatness, is also inherent in our ideas of our space. This was discovered many years ago by Prof. Sylvester, and, to denote it, he called our space a homaloid, or a homaloidal space. To us it always has three dimensions, and no more; and, just here, all readers may be advised not to try to *picture* to themselves any higher kind of space, since they must fail as utterly as they fail to see the ultra-violet rays of the spectrum. Moreover, it has not yet been demonstrated that any other kind of space actually exists in the physical world. This is a matter which can only be settled by physical experiments; and perhaps it is to be hoped that our old space will stand all tests, for, should it not, then all our science would have to be put on a new basis, at least in so far as related to space. So, you see, no one need be discouraged at his inability to perfectly conceive any other space than our common one. But, as the others are logically possible and mathematically true, and are necessary to get a complete knowledge of our own space, we will attempt to convey some notion of them. In our space we have length, breadth, and height, and to each of these corresponds a coördinate in analytic geometry. This is why we call ours a space of three dimensions, and we cannot picture any other dimension. But we find analytic geometry just as ready to deal with a space which

should be like ours in every other way, but should have another or fourth dimension; and this led to the question, "May not our space have a fourth dimension?"

Now, our only way of reasoning about the matter is to take analogous cases in the picturable spaces of two dimensions, and carry the analogies up from two to three, from three to four dimensions.

Let us take the easiest illustration. Suppose beings not living *on* the *surface* of a sphere, but *in* the *surface* of a sphere, and so having no conception of the third dimension of space.

Now, if they were so small as only to perceive a small portion of their surface, they might easily think it a plane, as the ancients thought our earth, and so their geometry would be the same as Euclid's.

But, if they were originally created so large in proportion to their spherical surface as to be immediately affected by its positive curvature, then they would never gather any experience of parallel lines, or of geometrical similarity between figures of different sizes. A straight line being the shortest distance between two points, then all their straight lines or geodesic lines would return upon themselves; and as also any two straightest lines on a sphere must meet somewhere, our imaginary surface men could never learn our theory of parallels and geometry, unless, as has been suggested, they should produce mathematicians sufficiently powerful first to imagine and investigate a surface in which two straight lines might be drawn so as to remain at the same distance apart to infinity; that is, if they could in any way be supposed to have the idea of infinity. Then, as Land says: "Reasoning on this, and a few more suppositions, they might discover the analytical geometry of the plane. Combining this with their original spherical theorems, some genius among them might conceive the bold hypothesis of a third dimension in space, and demonstrate that actual observations are perfectly explained by it. Henceforth there would be a double set of geometrical axioms; one the same as ours, belonging to science, and another resulting from experience in a spherical surface only, belonging to daily life."

In reference to our own science of to-day, the two analogous questions are:

1. May we not be drawing wrong conclusions about space from our limited experience of space, just as the Greeks concluded that the earth was flat?

2. If our conclusions so far are true, yet may there not be, in addition to the three dimensions we know, still another or fourth dimension in space?

The idea of space of four dimensions has been successfully used by Salmon, Clifford, and Sylvester, in their researches, and Cayley has published "Chapters in the Analytical Geometry of n Dimensions." Spaces of two and three dimensions with constant curvature have been carefully investigated by Beltrami, Helmholtz, and now Frankland. I mention these as among the most important and easily procurable writings on the subject. In reality there have been about a hundred books and memoirs treating of new or non-Euclidean space.

Of that kind of non-Euclidean surface now being discussed in *Nature*, a very pretty idea may be obtained by likening it to a hemisphere on which, when any moving point has reached the edge, it is supposed, without any jump or any further motion, to have reached the corresponding point on the opposite edge, so that the meridians, great circles, shortest lines, instead of intersecting twice, as they do on the earth, only intersect once and yet return upon themselves. This, like the sphere, is called a surface of positive curvature, in reference to the plane, which has no curvature.

Now, just as to the plane corresponds an uncurved or homaloidal space, so to a surface of positive curvature corresponds a space of positive curvature; and if the space in which we live can be proved to have the slightest positive curvature, it instantly follows that the universe is only finite in extent, and that every physical straight line, for example, every ray of light, if sufficiently produced, returns into itself.

Yours very truly,

George Bruce Halsted.

Johns Hopkins University, Baltimore, *May* 20, 1877.

"THE EARLY MAN OF NORTH AMERICA."

To the Editor of the Popular Science Monthly.

In an article in your March number, upon "The Early Man of North America," the writer says of the Esquimaux, "They are from their speech a branch of the Turanian family, and allied to the Hungarian, Turkish, Lapp, and Basque races." Whitney, in his work on "Life and Growth of Language," says of the Basque: "It stands entirely alone; no kindred having been found for it in any part of the world." He further says: "Attempts have been made to connect them" (the American languages) "with some dialect or family in the Old World, but with obviously unavoidable ill success. . . . There appears to be no tolerable prospect that, even supposing the American languages derived from the Old World, they can ever be proved so, or traced to their parentage." In the same article there is the statement that the Esquimaux "extend in scattered companies for nearly five hundred miles on the coast of Asia beyond Behring's Straits," while other writers assert that the Esqui-

maux have no kindred on the Eastern Continent.

As the philosopher of the nineteenth century claims that "in his hands theory is never divorced from fact," we who are not philosophers complain, as we have the right to do, when they flatly contradict each other and furnish no evidence to fortify their statements. We accept their dicta so long as they agree, but we object to a dictum which contradicts another dictum equally respectable. D. A. HULETT.

NEW YORK, *May* 12, 1877.

EDIBLE MUSHROOMS.

To the Editor of the Popular Science Monthly.

SIR: In the paper on "Mushrooms," etc., in the last number of your MONTHLY, I think Mr. Julius A. Palmer, Jr., uses the name of "Dr. Curtis, of South Carolina," for that of the great mycologist, Dr. Moses A. Curtis, of North Carolina, in connection with letters written to Mr. Sprague on "Mushrooms." Whether that is so or not, I am safe in saying that during our late war Dr. Moses A. Curtis wrote a work on "The Edible Fungi of North Carolina," illustrated with colored drawings by his son (I believe the Rev. Charles Curtis), and this manuscript work is still in existence. It is the result of Dr. Curtis's botanical investigations, as well as of his personal experience, as to which of the mushrooms are fit to eat. Many times, I am told, the good doctor had uncomfortable symptoms after trying a new mushroom, but you may be sure he did not stop until he learned more about it. His researches were begun in the war with a view to furnish such information to his people as would enable them to recognize edible mushrooms, and so supplement the poor diet so universal among even the better classes, but I believe he never cared to publish the work. I deem it but justice to the memory of Dr. Curtis to make this statement. THOMAS F. WOOD.

WILMINGTON, NORTH CAROLINA, *April* 30, 1877.

To the Editor of the Popular Science Monthly.

SIR: Will you permit a suggestion as to Mr. Herbert Spencer's descriptive term "negatively quantitative," and his specifications under it? It appears to me to belong to an undesirable class of definitions, because its defining part consists not only in asserting the absence of something, but in so asserting it as to require just as much the assertion of all the other absences that exist. That is to say, Mr. Spencer's definition, and his explanations of it, as cited in the MONTHLY of March, page 611, appear to me to necessarily imply the following preliminary proposition (which I do not think Mr. Spencer meant to imply): "A definition may consist of a statement that a single quality or characteristic is excluded from the thing defined." Now, of course, a definition, to be a good one, must accomplish two things, neither of which the above is: it must specify the qualities which the thing defined does possess; and it must exclude—not some one other, but—*all* others.

Further: is not the term "negatively quantitative" liable to be misunderstood from ambiguity? It seems to me that it may honestly be taken to mean either of the two following:

1. Being such as to exclude dealing with quantity or quantities.
2. Being such as to include, so far as it does deal with quantities, only what are called "negative quantities."

These are, of course, quite different meanings. It appears to me that Mr. Spencer applied the former, and that Mr. Halsted, in his communication to you, had in his mind the latter. If so, a misunderstanding was pretty likely.

I need not explain the benefit of avoiding the use for one purpose of terms already employed for another. And as I am a sincere admirer of Mr. Spencer, and of his great contributions to the advancement of sound thought, I hope you will not suppose I want to do anything in the way of attacking or fault-finding. F. B. P.

BOSTON, *April* 8, 1877.

THE HABITAT OF THE GAR-PIKE.

To the Editor of the Popular Science Monthly.

SIR: Since the publication, in the May number, of the first part of my article "Gar-Pikes, Old and Young," I have had information as to the occurrence of *Lepidosteus* in Black Lake, near Ogdensburg, New York; in the Patapsco River, Maryland, and in the Edisto, Ashepoo, and Combahee Rivers, South Carolina.

It being commonly supposed that *Lepidosteus* is rarely found outside of the Great Lakes or the Mississippi River and its tributaries, I shall be much obliged to your readers for any information as to its occurrence elsewhere. Particularly valuable would be facts as to the time and place of spawning; and the eggs or newly-hatched young are greatly desired.

BURT G. WILDER.

ITHACA, NEW YORK, *May* 10, 1877.

EDITOR'S TABLE.

THE STUDY OF NATURE IN SCHOOLS.

THE progress of scientific education is slow, but the evidences of its reality are unmistakable. Among the recent and most encouraging illustrations of it, we note the various arrangements in different colleges for making excursions and expeditions for observation and the collection of specimens by students who are sufficiently interested to extend their studies in these directions. The excursions are to be in charge of competent professors, and the time of vacation is to be devoted to the work. The idea is excellent, as it will combine the pleasure of travel and out-of-door activity with valuable mental acquisition, which need not be so close or severe as to neutralize the advantages of vacation. It is especially in geology and natural history that the benefits of such excursions will be most obvious. In the former of these sciences, field-observation and the inspection of rocks, minerals, and landscape features in different localities, are requisite to give reality to knowledge and redeem the study from the illusiveness and unreality of its pursuit in mere text-books. Botany and zoölogy also are subjects which call their devotees into field and forest, mountain and valley, and require a kind of peripatetic cultivation. These vacation excursions, half for pleasure and half for profit, are valuable indications both of the increasing interest of this class of mental pursuits, and of an increasing appreciation of the only proper method of carrying them forward; while the friends of science have reason for congratulation at these signs of improvement in rational scientific culture.

But the obverse of this picture should not be overlooked. We cannot conceal from ourselves that these excursions are things to be thankful for, very much because of the defects of normal study throughout the year. Of course the vacation is a season of liberty, and allows a range of wandering which school confinement does not permit; and it is possible that excursion-work may be nothing more than a freer extension of the habitual practice in the school—which, of course, is the way it should be. Yet the open study of Nature, in her living objects, is undoubtedly, in most cases, rather a contrast to college experience than a continuation of it. It is to be remembered that the college has still a definite somewhere in Nature, from which the student can have an outlook upon realities, although the traditional scholarship makes little account of this circumstance. There are natural objects enough at hand, and crowding the collegiate environment, to illustrate a wide range of scientific study, if it were the policy of these institutions to make such objects available for this purpose. It is well to go away to find and examine new things, where that is convenient, or where it may be specially necessitated; but it should not be held to imply that there are not abundant facilities all around and everywhere for securing the same general object. The study of Nature is beginning to be *recognized* as an important part of common education, but it remains yet to be *organized* for this end.

THE ACCUSATION OF ATHEISM.

IT has been suggested that, if Dr. Draper had entitled his book "A History of the Conflict between Ecclesiasticism and Science," instead of "between

Religion and Science," he would have disarmed criticism, and saved himself from a great deal of theological abuse; but he preferred to credit people who profess religion with having it and being influenced by it, in their treatment of science. There is, indeed, no ground for impeaching the general sincerity of religious people who are alarmed at the advancement of science, and denounce it as subversive of faith. Their difficulty is simply that of narrowness and ignorance, inspired by a fanatical earnestness. Atheism has now come to be a familiar and stereotyped charge against men of science, both on the part of the pulpit and the religious press. Not that they accuse all scientific men of atheism, but they allege this to be the tendency of scientific thought, and the outcome of scientific philosophy. It matters nothing that this imputation is denied; it matters nothing that scientific men claim that their studies lead them to higher and more worthy conceptions of the Divine power, manifested through the order of Nature, than the conceptions offered by theology. It is enough that they disagree with current notions upon this subject, and any difference of view is here held as atheism.

In this, as we have said, the theologians may be honest, but they are narrow and bigoted; and it is surprising that they cannot see that, in arraigning scientific thinkers for atheism, they are simply doing what stupid fanatics the world over are always doing when ideas of the Deity different from their own are maintained. And it is the more surprising that Christian teachers should indulge in this intolerant practice, when it is remembered that their own faith was blackened with this opprobrium at its first promulgation. In a very able article by Prof. Zeller, of Berlin, on "The Contest of Heathenism with Christianity," reprinted in The Popular Science Supplement, No. II., this interesting subject is taken up, and the writer remarks upon it as follows:

"To the heathen nations, the Christians were in the first place atheists; for in every age this name has been given to those who did not agree with the prevailing conceptions of the Deity; not only when they denied his existence, but when they sought to instill a more just and worthy idea of God. 'Down with the atheists!' this was the war-cry of the heathen mob against the Christians. It was with this cry, for example, that in A. D. 156 the venerable Bishop Polycarp was received on the race-course at Smyrna. The only gods the people knew anything about, whose temples they frequented, whose statues they worshiped, to whom they offered sacrifices and prayers, were denied by the Christians; they were declared to be the inventions of man's superstition, and sometimes to be evil spirits, devils. Can we wonder that the people who were still devoted to these gods felt the attack upon them to be an attack upon themselves, their most sacred and cherished possessions; that they were the more deeply incensed at it the more seriously they feared by toleration of it to lose the favor of the gods on whom their welfare depended? The reproach of atheism was therefore the most dangerous that could be brought against the Christians. In that 'Down with the atheists!' with which the yells of the mob greeted Polycarp at Smyrna, was included the sentence of death, which they at once proceeded to execute by preparing the stake. And the cry was followed in numberless cases by the same results. If any public misfortune, any alarming event occurred, which seemed to indicate the displeasure of the gods—a pestilence, a dearth, a flood, an eclipse, an earthquake—superstition was always ready to make the Christians responsible for it, as enemies of the gods; the exclamation was sure to be heard, 'The Christians to the lions!' Both the educated and uneducated have always attributed every other wickedness to the enemies of the gods, and so it was with the Christians. Being atheists, they were also criminals, and all manner of horrible stories were told of them. It was not enough that they were said to worship a god with the head of an ass, which we see represented to this day in a caricature of that period, the well-known mock crucifix in the Kircher Museum at Rome; it was said, also, that in their secret assemblies they practised all sorts of

horrors, killed and devoured children, and gave themselves up to frightful excesses. Scarcely any evils were attributed to the Jews in the middle ages by Christian fanatics which had not been before attributed to the Christians by heathen superstition."

It would be well if our theologians would remember these things when tempted to deal out their maledictions upon scientific men as propagators of atheism. For the history of their own faith attests that religious ideas are a growth, and that they pass from lower states to higher unfoldings through processes of inevitable suffering. It was undoubtedly a great step of progress from polytheism to monotheism; as it was cartainly a most painful transition to lose the idea of a social hierarchy of human or superhuman immortals constantly mixed up with human affairs and the working of Nature, and to substitute the idea of a solitary divine personality, related to mankind chiefly through a special theological scheme. But this was neither the final step in the advancement of the human mind toward the highest conception of the Deity, nor the last experience of disquiet and grief at sundering the ties of old religious associations. But if this be a great normal process in the development of the religious feeling and aspiration of humanity, why should the Christians of to-day adopt the bigoted tactics of heathenism, first applied to themselves, to use against those who would still further ennoble and purify the ideal of the Divinity? It cannot be rationally questioned that the world has come to another important stage in this line of its progression. The knowledge of the universe, its action, its harmony, its unity, its boundlessness and grandeur, is comparatively a recent thing; and is it to be for a moment supposed that so vast a revolution as this is to be without effect upon our conceptions of its Divine control? Is it rational to expect that the man of developed intellect, whose life is spent in the all-absorbing study of that mighty and ever-expanding system of truth that is embodied in the method of Nature, will form the same idea of God as the ignorant blockhead who knows and cares nothing for these things, who is incapable of reflection or insight, and who passively accepts the narrow notions upon this subject that other people put into his head? As regards the Divine government of the world, two such contrasted minds can hardly have anything in common. "As a man thinketh, so is he;" and as a man is, so will he think. If he is ignorant and stupid, his contemplation of divine things will reflect his own low limitations. He will cling to a groveling anthropomorphism and conceive of the Deity as a man like himself, only greater and more powerful, and as chiefly interested in the things that he is interested in. If he delights in the pious excitement of "revivals," he will think of the Almighty as the patron of camp-meetings, and as watching from on high with special solicitude the doings of Moody and Sankey in Boston. It is superfluous to say that men who look upon the universe as science has disclosed it cannot much sympathize with this view of the Deity and all that it implies. The profound student of science will rise to a more spiritualized and abstract ideal of the Divine nature, or will be so oppressed with a consciousness of the Infinity as to reverently refrain from all attempts to grasp, and formulate, and limit the nature of that which is "past finding out," which is unspeakable and unthinkable. Religious feeling may be awakened in both those minds; but its inspirations and its accompaniments will be as wide asunder as the poles. Our religious teachers ought in these days to have liberality enough to recognize this serious fact, and remembering that human nature is religiously progressive, as well as progressive in its other capacities, should abstain from copying the

bad example of narrow-minded heathen thousands of years ago, who treated the Christians very much as many Christians now treat those who are devoted to the gospel of science.

THE FAMILY AND THE STATE.

We commend to those students of social questions who are interested in their scientific aspects the essay "On the Evolution of the Family," by Mr. Herbert Spencer, which was begun in the June Monthly, and is concluded in our present number. The article is an instructive illustration of what is properly meant by social science, and it also shows what is gained for the subject by investigating its phenomena from the standpoint of evolution. It is obvious that we can know little of the nature of the family until we have a right idea of its origin; and it is equally evident that it cannot be intelligently and wisely dealt with, either by social or political arrangements, on a false theory of its derivation and consequent erroneous views of its constitution. It is a current belief that the family is as old as humanity, and is an indestructible element of human society, and much the same thing everywhere. Even such inquirers into the philosophy of political history as Mr. Maine commence their researches by assuming the family or patriarchal group as a starting point. But on the theory of evolution this form of the domestic relations must be accounted for. The patriarchal condition was an outgrowth of earlier conditions, the complex resultant of a preëxisting state which there is reason to believe was far more prolonged than the period that has elapsed since the family was instituted. Be that as it may, the point of view now gained is that of the family as a growth, a product of the slow interaction of various natural agencies, and an institution therefore that is liable to impairment, disintegration, and decay.

This conception of the family gives an interest to the question of its relation to the state that no other hypothesis enforces. The family is older than the state, and grew up without it by natural laws and through long domestic experience and social discipline. The state is a subsequent development, a new direction of the power of society which is liable to be so exercised as to disturb and modify in serious ways the domestic relations. A child cannot build a house, but it can burn it down; the state did not make the family, but it can mar and destroy it. If, as Mr. Spencer alleges, "the salvation of every society depends on the maintenance of an absolute opposition between the *régime* of the family and the *régime* of the state," governmental tendencies become a matter of the gravest social concern. And these considerations acquire additional force in a country like this, where the whole people are given over to politics, and where there is a universal passion for experimenting with society under a superstitious delusion in regard to the omnipotence of legislation. If the principle laid down by Spencer be a true one, then are the functions of government sharply limited, and, by transcending them, the state to that extent usurps domestic functions, and becomes destructive of the family. The family grew up and became consolidated, as we may say, under pressure of necessities and responsibilities that could not be escaped, as there was no state upon which parents could roll off their burdens. But the state has come, and besides its essential duty of protecting the common rights, it is becoming more and more called upon to take care of the people, to improve the condition of the people, to take charge of their children, in short to assume the "parental" function. We have already gone so far in our state meddling with the work of education and relieving parents from the responsible care of their children, that the demand is now urgently made by

progressive teachers and advanced educational reformers that the government shall follow out the policy to its logical and consistent consequences, and assume the complete educational control of the young. From the time of weaning to graduation, the state (that is, the politicians who at any time happen to be in office) will hire the teachers and pay them, prescribe the studies, furnish the books, build the schoolhouses, and administer the discipline by which character is to be formed. This is an invasion of the domestic sphere, and an abrogation of those domestic functions by which the family was called into existence and has ever been maintained. Our school system is applauded on account of its imposing parade of statistics, its profuse expense, and the millions of children that the state has got charge of; but, when its indirect influences are taken into account, it may be found that, like most other human contrivances, it entails evil as well as good. Which shall preponderate, it remains for time to tell.

LITERARY NOTICES.

New Lands within the Arctic Circle. Narrative of the Discoveries of the Austrian Ship Tegetthoff, in the Years 1872–1874. By Julius Payer, one of the Commanders of the Expedition. With Maps and numerous Illustrations, from Drawings by the Author. Pp. 399. New York: D. Appleton & Co. Price, $3.50.

The honor will be unhesitatingly accorded to Lieutenant Payer of having written the most deeply-interesting volume that has yet appeared on arctic adventure and exploration. We have rarely been so fascinated by a book of any kind, upon any subject. The experiences of the party were tragic and of thrilling intensity, and the narrative of them is in a remarkable degree vivid and graphic; so that, with the numerous and admirable illustrations, all drawn on the spot from Nature, we are made deeply to participate in the feelings of the heroic group of adventurers who were so long locked up amid the terrible desolations of Nature in the arctic region.

In a preliminary notice by the translator, the leading features of the expedition are thus summarized:

"The interest which will be excited afresh in arctic discovery and adventure will doubtless sharpen the interest in the volumes which record the fortunes of the Austrian Expedition; and we venture to affirm—without undue partiality—that, though the history of arctic exploration and discovery abounds in records of lofty resolution and patient endurance of almost incredible hardships, the narrative of the voyage of the Tegetthoff will be found to fall below none in these high qualities. The mere destiny of the vessel itself equals, if it does not exceed, in the element of the marvelous, anything which has before been recorded. Surely this is borne out when we think that, on August 20, 1872, the Tegetthoff was beset off the coast of Nova Zembla; remained a fast prisoner in the ice, spite of all the efforts made by her officers and crew to release her; drifted, during the autumn and the terrible winter of 1872—amid profound darkness—whither they knew not; drifted to the 30th of August in the following year (1873), till, as if by magic, the mists lifted, and, lo! a high, bold, rocky coast—latitude 79° 43′ north, longitude 59° 33′—loomed out of the fog, straight ahead of them. Close to this land—which could be visited with safety only twice, on the 1st and 3d of November of that year—the ship remained still fast bound in the ice. Not till the winter of 1873 had passed, and the sun had again returned, was it possible to explore the land which had been so marvelously discovered. On the 10th of March, 1874, the sledge-journeys commenced, and terminated May 3d, after 450 miles had been passed over, and the surveys and explorations completed, which enabled Payer to write the description of Kaiser Franz-Josef Land (pp. 258–270), which shows that other still undefined lands, with an archipelago of islands, have been added to the geography of the earth."

For more than two years the party were prisoners in their ship, of which they had lost all control, and, after passing two horrible winters in this distressing helplessness, it became clear that they must quit the ship or perish, and, in fact, there was small hope of saving their lives even by leaving it. Three boats were loaded with necessaries, and they started, May 20th, to dig their way through the deep snows and amid the mountainous ice-hummocks to open water. We extract from Payer's diary:

"The first day's work for twenty-three men, harnessed to boat or sledge, was the advance of one mile; and even this rate of progress, small as it was, was not constant. Many days it did not amount to half a mile. The sledges sank

deep and stuck fast in the snow. We had to pass three times heavily laden, and twice empty, over every bit of the road, and half our number were scarcely able to move a sledge or boat. After the exertion of some days, raw wounds appeared on the shoulders of several, and, to add to our trials, we suffered intensely from thirst. Nine men were sent back to the ship to bring away the jolly-boat and more stores, and it took just three hours to do the distance which it had cost the advance party eight days to accomplish. On our return to the boats, we found their crews were sitting up, and looking out like young birds in a nest, to see what we had brought from the ship. . . . Happy the man who has any tobacco; happy he who after smoking his pipe does not fall into a faint; happy, too, the man who finds a fragment of a newspaper in some corner or other, even if there should be nothing contained in it but the money-market intelligence, or, perhaps, directions to be followed in the preparation of pease-sausage. Enviable is he who discovers a hole in his fur coat which he can mend; but happiest of all are those who can sleep day and night. Of these latter, some have stowed themselves away under rowing-seats, and above them reposes a second layer of sleepers; but nothing is visible of either party but the soles of their feet. . . . The end of the Franklin Expedition, and the history of the two skeletons which were found in the boat, is told again for the twentieth time—a story which never fails to produce a harrowing effect, and to rouse the firm and resolute to yet greater efforts and self-command. . . . One solace is left us—the solace of smoking. Some, indeed, have exhausted their whole stock of tobacco. He who has half a pouch of it at his disposal is the object of general respect, and the man who can invite his neighbor to a pipe of tobacco and a pot of water is considered to do an act of profuse liberality. Tobacco becomes a medium of exchange among us, and provisions are bought and paid for with it, its value rising every day. There is no difference between day and night, and Sundays are only distinguished by dressing the boat with flags. In this enforced idleness passed away the days between the 9th and 15th of June, save that on the 14th we changed our place by three hundred yards, in order to select a more convenient spot for seal-hunting, and to keep up the appearance of traveling."

The unparalleled hardships of this struggle may be inferred from Lieutenant Payer's remark, page 364, that, "*after the lapse of two months of indescribable efforts, the distance between us and the ship was not more than nine English miles.*"

But the open sea was at length reached, and on the 15th of August the boats were dressed with flags, ballasted, the sledges left behind, and the expedition put off. The party had passed ninety-six days in the open air after leaving the Tegetthoff, when a small boat was descried, with two men in it, apparently engaged in bird-catching; and, upon turning the corner of a rock, two ships were discovered, within a few hundred yards. They were Russian vessels, engaged in salmon-fishing; and the strangers were received on board with mingled feelings of wonder and sympathy. Lieutenant Payer remarks:

"No grandees could have been received with more dignity than we were. At the sight of the two ukases which we had received from St. Petersburg, and which required all inhabitants of the Russian Empire to furnish us with all the help we needed, these humble seamen bared their heads and bowed themselves to the earth. We had an example before us to show how orders are obeyed by the subjects of that empire a thousand miles from the place where they were issued. But we were received not only in this reverential manner, but were welcomed with the greatest heartiness, and the best of everything on board was spread before us—salmon, reindeer-flesh, eider-geese, eggs, tea, bread, butter, brandy. The second skipper then came on board, and invited us to visit him—the first of a series of invitations. Dr. Kepes was very pressingly invited, for he had a sick man on board his vessel, and our doctor returned with an *honorarium* of tobacco in his hand. These simple Russian seamen of the arctic seas freely produced their little stock of good things to give us pleasure; and one of them, after observing me for a long time, and thinking that I did not express myself sufficiently strongly for a happy man, persuaded himself that something was the matter with me, and that I wanted something. Forthwith he went to his chest, and brought me all the white bread he had, and the whole remaining stock of his tobacco. Though I did not understand a word he said, his address was full of unmistakable heartiness, and so far needed no interpreter."

We have preferred to let the author of this work speak for himself rather than to attempt any description of it, which would certainly be unsatisfactory within our narrow limits. But we may add that it is a volume of great scientific interest. For half a century arctic adventure has been inspired by a sentiment of rivalry to reach the pole, although more and more it has been recognized that its real object should be the extension of our knowledge of Nature under its remarkable arctic aspects. Lieutenant Payer has entered fully into this view; and his volume is not only charming as a narrative, but contains a great deal of important scientific information.

The Cooking Manual; or, Practical Directions for Economical Every Day Cookery. By Juliet Corson, Superintendent of the New York Cooking School. New York: Dodd, Mead & Co. Pp. 144. Price, 50 cents.

Miss Corson has done well to give the public this result of her experience in culinary teaching, in a form so cheap that it may have the widest possible usefulness. She is a common-sense woman, and takes up the subject from a point of view that is thoroughly practical. The motto of her book is the following significant question, "How well can we live if we are moderately poor?" and it is the object of her little volume, as it has been the object of her school, so to present the subject of cooking and household management as to answer this question. Her object in preparing it is thus stated: "This book is intended for the use of those housekeepers and cooks who wish to know how to make the most wholesome and palatable dishes, at the least possible cost. In cookery, this fact should be remembered above all others—*a good cook never wastes.* It is her pride to make the most of everything in the shape of food intrusted to her care, and her pleasure to serve it in the most appetizing form. In no other way can she prove her excellence, for poor cooks are always wasteful and extravagant." To the prejudice against foreign ways of cooking Miss Corson replies very effectually, pointing out that the two great objects to be ever secured in the kitchen—the art of utilizing every part of food, and of making food the most palatable and enjoyable—are eminently French.

Miss Corson says, "The day has passed for regarding cooking as a menial and vulgar labor." She is very sanguine; we wish we could believe it. We wish we could see some more decisive signs that it is passing away; we wish we could see some faint indications that it will have passed away in a hundred years! Our school system stands in the way of it, and where are the symptoms of its decline?

Miss Corson's book is full of excellent information, scientific hints, practical suggestions, and plain receipts, descriptive of the preparation of many important dishes, and the publishers have got it up in a neat form, with good, clear type, that can be easily read. We believe it will be found eminently trustworthy as a kitchen handbook.

The Best Reading: Hints on the Selection of Books; on the Formation of Libraries, Public and Private; on Courses of Reading, etc., with a Classified Bibliography for Easy Reference. Fourth revised and enlarged edition, continued to August, 1876, with the Addition of Select Lists of the best French, German, Spanish, and Italian Literature. Edited by Frederick Beecher Perkins. New York: G. P. Putnam's Sons. Pp. 343. Price, $1.75.

This guide will be valuable to all who buy books for private libraries or public collections. It has been tried and found successful. It names the best books now usually in the market in the chief departments, and on the leading topics of current and general literature, with their editions and retail prices. It is conveniently arranged for ready use, and will give the book-buyer a large amount of valuable information, that will help him in making judicious selections, either on the small or the large scale.

The Milton Anthology: Selected from the Prose Writings. New York: Henry Holt & Co. Pp. 486. Price, $2.

Milton's prose works have been so eclipsed by his poetry that they are popularly known only by hearsay; yet so great is their merit, both in a literary point of view and as containing the most able and eloquent defense of civil and religious liberty which had been given to the world up to his time, that the plan of collecting some of his best papers in a handy volume like this deserves to be commended, and will no doubt be well appreciated. Though there is much in these writings that reflects the spirit and circumstances of the times which produced them, there is much also of permanent interest, and which will have an enduring place in English literature.

The Geometrid Moths of the United States. By A. S. Packard, Jr., M. D. Pp. 607. With numerous Plates. Washington: Government Printing-Office.

This elaborate work forms Volume X. of Dr. Hayden's "Report of the Geological Survey of the Territories." The author

notes a striking and unexpected similarity between the insect fauna of Colorado and the Ural and Altai Mountains. He believes that a careful examination of the existing insects of the Western country will throw light on the extinct forms which abound in the Tertiary of that region. From an economic point of view, he is of the opinion that a systematic account of the insect family which embraces the measuring-worms—so many of which are injurious to vegetation—cannot but be useful to agriculturists.

Moral Maxims for Schools and Families. By C. C. Baldwin. Third edition. Pp. 16. Price 10 cents. Petersburg, Va.: Darcy, Paul & Co.

This little pamphlet raises no questions of ethics, but, assuming the fundamental canons of morality and rules of conduct, it aims to drive them home into the minds of the young by brevity and sharpness of statement, so as to make the most indelible impression. It is interspersed with interesting illustrations of the sayings and doings of great men, which serve to give interest to the work. The idea is a good one, and well carried out within its compass; it is used in the public free schools of Virginia, and is a candidate for adoption in primary schools everywhere.

The Symbolical Language of Ancient Art and Mythology. By R. P. Knight. Pp. 267. New York: J. W. Bouton. Price, $3.

The so-called "pagan" religions of antiquity—the religions of Greece and Rome, of Babylonia and Assyria—so far as we get a knowledge of them from a superficial reading of ancient authors, appear to rest on a basis of childish imaginations, for their dogmatic side, while on their moral (or rather immoral) side they seem to have their roots in unbridled lust and debauchery. This view of pagan religions is still held by the vulgar, and not very long ago was current even among the learned. The author of the present work rendered valuable service to the philosophy of religion when, amid much obloquy, he devoted himself to a patient and dispassionate study of this subject, and showed that, like all other religions, those of antiquity were in their origin the expression of man's highest aspirations. Among the topics learnedly discussed by the author are the mysteries and orgies, phallic worship, the sacred emblems of the various gods, etc. The present edition of Knight's work is edited by Dr. Alexander Wilder, who adds an introduction, some notes, and a complete index. Further, the notes, which in the original edition are mostly in foreign languages, are here translated into English.

An Analysis of Religious Belief. By Viscount Amberly. From the late London edition. Complete. Pp. 726. New York: D. M. Bennett. Price, $3.

The chief interest of this formidable volume lies in the fact that it is the production of a young English nobleman, who, notwithstanding the powerful influences brought to bear upon him to maintain his reputable position, chose to be free in the matter of thought, and had the courage to express and the determination to publish his opinions, regardless of their unpopularity. The volume indicates extensive and systematic reading, rather than much depth or originality of thought, and to persons who have a taste for skeptical literature it will have the freshness of an elaborate restatement of objections to religious dogma. Lord Amberly believes in the universality of the religious sentiment, as a part of the mental constitution of human nature—as a natural and not a supernatural thing—but he discredits its intellectual accompaniments as embodied in the doctrines and creeds of all religions. He professes to take the scientific standpoint, and to write in the scientific spirit, but we question if his book would take any rank as a scientific or authoritative contribution to the subject. Its scheme was too large, the man was too young, and had done no preliminary work in any of the special departments of science, to give him the power and maturity necessary to deal with so important a theme at the present time. Without comparing his work with that of Mr. Buckle, his position as regards science is not unlike that of the author of the "History of Civilization in England," who knew a great deal about scientific literature, and was much influenced by its method, but was not strong and thorough and well grounded in the

sciences which had a vital bearing upon the course of his large discussion. If Lord Amberly had concentrated himself upon some minor branch of his broad inquiry, and worked it out with deliberation, his chances of recognition in the future would probably have been much more promising than they will be with his more ambitious undertaking.

The Radical Review. Issued quarterly. Edited by Benjamin R. Tucker. Pp. 204. Price, $5 per year. New Bedford, Mass.

The first number of this periodical vindicates its radical and independent character. Its object is stated to be "the thorough, fearless, and impartial discussion of all sides of all subjects pertaining to human welfare, whether social, economic, scientific, literary, æsthetic, or religious." It will show no partiality to any particular school or special system of belief, but the labor question and the organization of industry will receive a prominent share of attention. It opens with an able paper, by W. J. Potter, on "The Two Traditions, Ecclesiastical and Scientific," of which the following passage is a good example:

"But this scientific view of tradition—now commonly styled the doctrine of evolution—starts questions that concern religious and moral faith more vitally than any we have yet considered. The objection that the dignity of the human race is assailed, if man be thus linked in natural kinship with the brute animals, is becoming antiquated, and needs no consideration. To ridicule the theory, and oppose those who hold it with theological abuse, neither intimidates scientific men nor abolishes the facts upon which they claim that the theory rests. To ask if you want a monkey for an ancestor may raise a laugh among the bystanders; but Science is not answered by a laugh, and does not consult the caprice of human wishes so much as the purport of Nature's facts. But even if it were a question of the dignity of the human race, it might be replied that it is better to have risen from an ape than, according to the popular theological theory, to have fallen from an angel. It is more honorable to be climbing up than slipping down. And there are species of animals with whom we might more proudly claim cousinship than with some specimens of mankind. But this concern lest human dignity is to suffer from any earnestly advocated theory of science is puerile."

Lysander Spooner furnishes a very incisive and unsparing article entitled "Our Financiers: their Ignorance, Usurpations, and Frauds," which cleaves the question through to first principles. A fine poem is contributed by Mr. E. C. Stedman; and the department of current literature is ably treated. It contains a discriminating review of Mr. J. N. Larned's "Talks about Labor, and concerning the Evolution of Justice between the Laborers and the Capitalists." We like this periodical, all except its dismal pall of a cover.

Dynamics. By J. T. Bottomley. Pp. 140. New York: Putnams. Price, 75 cents.

The fundamental principles of "Dynamics," or theoretical mechanics, are here set forth and demonstrated as satisfactorily as it is possible to do so for the tyro in mathematical science. In cases where the subject-matter requires a higher degree of mathematical knowledge, the author contents himself with giving clear statements of propositions and of the meanings of formulas, reserving demonstrations for a time when the pupil will be better able to appreciate them.

Smithsonian Report. 1875. Pp. 422. Washington: Government Printing-Office.

Besides the special annual report of the Secretary, Prof. Joseph Henry, this volume contains a number of memoirs and treatises on scientific subjects, both original and selected. Among the translated pieces are a "Eulogy on Alexander Volta," and De Candolle's "Report on the Transactions of the Geneva Physical and Natural History Society." Among the original contributions is a paper by Mr. Henry Gilman on "Ancient Man in Michigan;" and one by Dr. C. C. Abbott, on "The Stone Age in New Jersey." Both of these memoirs, and more especially the latter, are illustrated with numerous woodcuts.

Vegetable and Animal Cellulose. By Thomas Taylor. Pp. 8. From *Field and Forest.*

The author describes the method by which he detects the presence of cellulose in its various forms. This substance is, according to him, a constant ingredient in the organs and blood even of the higher animals, man included.

Acoustics, Light, and Heat. By W. Lees. Pp. 300. New York: Putnams. Price, $1.50.

The student who is acquainted with the elements of mathematical and physical science will find this little work a very convenient manual for self-instruction in the branches of science of which it treats. The illustrations are very numerous, and greatly facilitate the understanding of the text.

Proceedings of the Poughkeepsie Society of Natural Science. Vol. I., Part I. Pp. 150.

This work contains a number of very valuable memoirs, among which may be named the following: "White Mildews," by W. R. Gerard, who also has a learned paper on "Insects as Food;" two papers on the "Thermoscope," by Prof. L. R. Cooley; "Habits of the Wasp, *Polistes fucatus*," by Rev. H. T. Hickok; "Fungus-Eating," by Dr. E. H. Parker; and "Inclination of the Earth's Axis," by C. B. Warring.

Western Review of Science and Industry. Monthly. Pp. 64. Kansas City, Mo.: *Journal of Commerce* print. Price, $2.50 per annum.

We have received the first number of the above-named periodical, which we cordially welcome to the field of scientific journalism. It contains articles, original and selected, on topics connected with archæology, physiology, engineering, meteorology, and agriculture. The editor aims at filling his pages with useful and practical information for the people, conveyed in plain and simple language. This enterprise deserves, and we hope will receive, liberal support from the public.

Analysis of Milk. By E. H. von Baumhauer. Pp. 34. New York: Trow & Son print.

We have here, reprinted from the *American Chemist*, Dr. Carrington Bolton's translation of a paper read by Mr. Baumhauer at the Buffalo meeting of the American Association. It contains a description of a new method for determining the essential constituents of milk, especially designed for the use of chemists who may be called on to testify as experts in courts of justice.

Myelitis of the Anterior Horns. By E. C. Seguin, M.D. Pp. 120. New York: Putnams. Price, $1.50.

This monograph is of interest only to medical men. The substance of it was contained in a lecture by the author, printed for private circulation only. In the present volume a number of new cases of the disease are cited.

The Metric System. Pp. 12. Boston: Press of Rockwell & Churchill.

This is the report of a standing committee of the Boston Society of Civil Engineers, favoring the adoption of the metric system of weights and measures. The committee first report on the growth of this system in public favor; then they state the result of invitations to united action addressed by the Society to kindred organizations throughout the country; next follows the text of the Society's memorial to Congress praying for the enactment of laws establishing the metric system.

The Ancient Glaciers of New Zealand. By I. C. Russell. Pp. 13. With Map.

This is a paper reprinted from the "Annals" of the New York Lyceum of Natural History. The facts noted by the author seem to point to a time of extreme cold in the southern hemisphere, answering to the glacial epoch of the northern.

Natural History of Illinois. Pp. 76. With Plates. Bloomington, Ill.: Pantagraph Printing-House.

We have here Bulletin No. 1 of the Illinois Museum of Natural History, containing papers on "Illinois Crustacea," "The Tree in Winter," "Sodic Pinate as a Test for Lime," a "Partial Catalogue of the Fishes of Illinois," "Parasitic Fungi," and "The Orthoptera of Illinois."

Topographical Surveys and the Public Health. By J. T. Gardner. Pp. 10. Albany: *Argus* print.

The thesis here defended by Mr. Gardner is, that the sources of many prevailing diseases are to be found in various natural conditions of the earth's form and substance, as well as in soils polluted by man. The geographer and the physician must work together in the study of the public health.

Geographical Surveys in the United States. By G. K. Warren. Pp. 28. Washington: Judd & Detweiler.

General Warren here undertakes to "correct the erroneous estimate of the geographical work of officers of the United States, made by one of our countrymen," viz., Prof. J. D. Whitney, in his article on "Geographical Surveys," which was published in the *North American Review* for July, 1875.

Report of the New York Meteorological Observatory (1874–'75.) By D. Draper.

Mr. Draper gives a description of an improvement iu the rain-gauge, and of a self-recording pencil thermometer — both being the fruits of his own researches and mechanical ingenuity. The report further contains the usual annual and monthly tables of meteorological phenomena.

A Century's Progress in American Zoölogy. By A. S. Packard, Jr. Pp. 8.

Prof. Packard, within the narrow limits of this too brief essay, contrives to give a very readable account of the progress of zoölogy in the United States. To Barton he assigns the honor of being the first American zoölogist whose works have been published here. Barton's memoir on the "Fascination of the Rattlesnake," and on the "Generation of the Opossum," appeared, the first in 1796, and the second in 1801. At present zoölogy in the United States is, according to Prof. Packard, very backward as compared with Germany, France, and England. We are about on a level with the Scandinavians and the Dutch; but, with our energy and native ability, and the aid of well-endowed colleges and museums, we may hope hereafter to compete even with Germany.

Kindergarten Messenger. Cambridge: Elizabeth P. Peabody. Pp. 32. Six numbers a year. Subscription price, $1 per annum.

It is to be hoped that the energetic editor and publisher of this useful magazine will receive such encouragement from the public as will warrant her in continuing its publication. The Kindergarten system has no more able exponent in the United States than Miss Peabody.

PUBLICATIONS RECEIVED.

Gold and Debt. By W. L. Fawcett. Chicago: S. C. Griggs & Co. Pp. 270. Price, $1.75.

Handbook of Hygiene. By G. Wilson, M. D. Philadelphia: Lindsay & Blakiston. Pp. 520. Price, $3.50.

Turkey. By J. Baker. New York: Holt & Co. Pp. 515, with Two Colored Maps. Price, $4.

Annual Record of Science and Industry. By S. F. Baird. New York: Harpers. Pp. 845. Price, $2.

Lightning Protection. By H. W. Spang. Philadelphia: Claxton, Remsen & Haffelfinger. Pp. 180. Price, $1.50.

Ancient Society. By L. H. Morgan, LL. D. New York: Holt & Co. Pp. 576. Price, $4.

Anonymous Hypothesis of Creation. By J. J. Furniss. New York: C. P. Somerby. Pp. 54.

Personal Immortality. By J. Oppenheim. New York: C. P. Somerby. Pp. 98.

Theoretical Chemistry. By Dr. Ira Remsen. Philadelphia: H. C. Lea. Pp. 232. Price, $1.25.

Primer of Chemistry. By A. Vacher. Philadelphia: Lindsay & Blakiston. Pp. 116. Price, 50 cents.

Forces of Nature. Part I. By A. Guillemin. New York: Macmillan. Pp. 40, with Illustrations. Price, 40 cents.

Atlas of the Geology of a Portion of the Uinta Mountains. By J. W. Powell. New York: Julius Bien, lithographer.

Report of Ohio State Fish Commission. Columbus: Nevins & Myers print. Pp. 96.

Ages of Sun and Fixed Stars. Pp. 4. Meteoric Fireballs. Pp. 7. By D. Kirkwood.

Utah Dialects. By E. A. Barber. Extracted from Hayden's Reports. Pp. 13.

Physiology of the Brain. Pp. 15. Reflex Motor Symptoms. Pp. 16. By Dr. E. Dupuy. New York: Appletons.

Errors of Refraction. By Dr. F. A. Munson. Albany: Riggs print. Pp. 11.

Valuation of Fertilizers. By A. R. Ledoux. Raleigh, N. C.: *Observer* print. Pp. 15.

Western Diptera. By C. R. Osten-Sacken. From Hayden's Reports. Pp. 163.

Report of the Directors of the Philadelphia Zoölogical Society. Pp. 36.

Growth of Children. By Dr. H. P. Bowditch. From Massachusetts Health Board Report. Pp. 51.

Kings County Medical Society Proceedings. Pp. 18.

Eruptive Mountains in Colorado. By Dr. A. C. Peale. From Hayden's Reports. Pp. 14.

Bulletin of the Geographical and Geological Survey of the Territories. T. V. Hayden in charge. Vol. III., No. 1, pp. 185; No. 2, pp. 339. Washington: Government Printing-Office.

Bulletin I. of United States Entomological Commission. Washington: Government Printing-Office. Pp. 12.

Quadrature of Circle. By R. K. Carter. Chester, Pa.: Spencer print. Pp. 12.

Rules of English Conversation Club at Kolozsvar. Pp. 19.

Johns Hopkins University Second Annual Report. Pp. 50.

Blue-Glass Cure. By Dr. E. B. Foote. Pp. 63. Price, 10 cents.

Overturning the World. By Dr. G. M. Ramsey. New York: McBreen print. Pp. 27.

Dakota Calendar. By Lieutenant-Colonel G. Mallery. From Hayden's Reports. Pp 25.

Paleontological Paper. By Dr. C. A. White. From Hayden's Reports. Pp. 30.

Sugar-Refinery of Havemeyers & Elder. From "Industrial America." Pp. 18.

Report on the Retreat for the Insane. Hartford, Conn.: Case, Lockwood & Brainard Co. print. Pp. 36.

Steam-Engine. By F. J. Bramwell. London: Macmillan. Pp. 62. Price, 6*d.*

Distilled Water from Service-Steam. By C. E. Munroe. From *American Chemist.* Pp. 12.

Superficial Deposits of Nebraska. By Dr. S. Aughey. From Hayden's Reports. Pp. 31.

Self and Cross Fertilization of Flowers. By T. Meehan. Pp. 8.

Circular Eight of Johns Hopkins University. Pp. 12

The New Century. Pp. 46. $1 a year.

Natural Resources of the Black Hills. By W. P. Jenney. Washington: Government Printing-Office. Pp. 71.

Proceedings of American Chemical Society. Vol. I., No. 3. Pp. 77.

Pennsylvania College Monthly. Gettysburg: Wible print. Pp. 28.

Vick's Floral Guide, Rochester, N. Y. Pp. 30.

Poisonous Mushrooms. By Dr. I. Ott. Pp. 6.

POPULAR MISCELLANY.

Reopening of an Old Route into Siberia.—Fully three hundred years ago the Russians carried on an extensive trade between Archangel and the settlements on the Obi and Yenisei. About the same period the Kara Sea was navigated by English and Dutch mariners, in search of a northeast passage to Japan. The Russians employed wretched flat-bottomed boats, called *kotchkies*, and in these they braved all the dangers of navigating the stormy Kara Sea. But, till quite lately, this route to the interior of Siberia was abandoned, and the belief was generally entertained that the existence of ice in the Kara Sea presented an insuperable obstacle to navigation. Recent expeditions to the mouths of the Obi and Yenisei, and up those rivers for hundreds of miles, have demonstrated the entire feasibility of this route to the interior of Siberia. The influence of the Gulf Stream and equatorial currents on the temperature of the Kara Sea is apparent from the fact that its waters are as much as 18° or 20° warmer than the waters in the same latitudes off the east coast of Greenland or in Davis's Strait. Of Siberia, the country to be opened up to commerce by the navigation of the Kara Sea, M. de Lesseps declares that it is the richest country in the whole world as regards its vegetable, mineral, and animal products. The great rivers of Siberia flow from the south to the north, forming a vast fan which widens in the interior of the country, to the great advantage both of vegetation and of commerce. The Obi, with its confluent the Irtish, affords a navigable highway into China.

The Art of the Farrier.—It is with regret that we are forced by want of space to present to our readers, in the unsatisfactory shape of a synopsis, a valuable article on "The Art of the Farrier," by Dr. D. D. Slade, published in the *Bulletin of the Bussy Institution*, vol. ii., Part I. In the state of Nature, we are there told, the growth and wear of the horse's hoof are in perfect equilibrium; in the domesticated state wear exceeds growth, and some means of protection must be devised. But this again destroys the balance, and growth is in excess. This excess must be removed either by natural wear of the bare hoof or by artificial means. The farrier's art consists in removing this excessive growth. The hoof of the young animal, before it has been shod, needs little or no preparation from the farrier's hands. The foot that has already been shod must have the nails extracted, and its ground surface cut down to the proper level. The growth is greatest at the toe; in leveling the wall, reduce the hoof at the toe to a level with the unpared heel. The shoe must not remain on the hoof more than one month at a time.

The heel seldom needs paring away, being usually worn away by the motion between the iron of the shoe and the horn. The process of "opening up" the heel destroys that portion of the foot which was designed by Nature as a defense against its contraction; this defense should never be mutilated. The practice of paring the sole and destroying the bars is to be condemned so long as the parts are healthy; it exposes the sensitive portions beneath to injury. The frog should be retained in its integrity. Rasping the wall after the application of the shoe cannot be too strongly condemned; it destroys the polish of the external layer of horn which protects the layers beneath, rendering the crust brittle.

The shoe ought to present a concave surface to the ground, and a plane surface to the foot. But, where the sole has been mu-

tilated by unskillful shoeing, the concave and plane surfaces have to be reversed. Whatever form is adopted, the shoe must fit the foot, its outline corresponding exactly to its ground-surface. The shoe must be of the same thickness throughout; where calks are required, they should be of equal height at heel and toe. The number of nails to each shoe, for a saddle or light-draught horse, need not be more than five or six in the fore and seven in the hind, but more widely distributed than they usually are. The hold of the nails should be short. The slight scorching of the horn-fibres by the application of a hot shoe has rather the effect of preserving them against untoward influences than of inflicting injury.

Disease often produces changes which require a modification of the system advocated above. In caring for the feet all that is needed is strict attention to cleanliness. They should be daily sponged with clear water, and afterward the parts above the hoof rubbed dry. The unmutilated sole forms in itself the best defense against the extremes of dryness or moisture, and "stuffing" and other artificial measures are worse than useless if the natural sole has been preserved. Placing the animal on a perfectly level floor will promote a sound condition of the feet, and conduce to the general health of the horse.

A Plague of Rabbits in New Zealand.—Some years ago rabbits were introduced into South Australia from England; later, a like importation was made into New Zealand. Now these rodents are a formidable pest in those countries, and it has become a question of extreme urgency how they can be exterminated. In New Zealand a commission has been instituted by the Government to inquire into the subject, and devise a remedy. Already, though only a few years have passed since the introduction of the rabbits, large tracts of rich pasture-land have been converted into wilderness, and sheep-farming and cattle-raising are becoming impossible. Farmers that used to keep 15,000 or 16,000 sheep can now hardly keep as many hundred. Land-owners employ men and dogs to destroy the rabbits, but, though the number killed is enormous, the evil continues without serious abatement. One land-owner inclosed with a stone-wall an area of 10,000 acres, the work taking seven years to complete, and involving an expenditure of £35,000. About 500,000 rabbit-skins were exported from Hobart Town in 1874. It is proposed to introduce from England, if possible, several natural enemies of the rabbit, such as stoats, weasels, ferrets, and hawks.

Metric Weights and Measures in Massachusetts.—Below we give the main provisions of a law recently enacted by the Legislature of Massachusetts, legalizing the metric system of weights and measures, in conformity with the laws of the United States. Other States, in legislating upon this subject, will doubtless frame their laws according to the model here set before them by the Commonwealth of Massachusetts:

SECTION 1. From and after the passage of this act, it shall be lawful, throughout the Commonwealth of Massachusetts, to employ the weights and measures of the metric system, and no contract or dealing or pleading in any court shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system; and the metric weights and measures received from the United States, and now in the Treasury of the Commonwealth, may be used and taken as authorized public standards of weights and measures; and these authorized standards shall in no case be removed from the Treasury, except under necessity for their preservation or repair.

SEC. 2. The following tables shall be recognized in the construction of contracts, and in all legal proceedings, as establishing, in terms of the weights and measures now in use in the State of Massachusetts, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing, in customary weights and measures, the weights and measures of the metric system. (Here follow the tables.)

SEC. 3. The Treasurer is hereby authorized and directed to procure duplicate sets of the metric weights and measures, conformable to the standards now in the Treasury; of which two sets shall be retained for the use of the Treasurer and his deputy, and from which there shall be furnished one set to the treasurer of each shire town in the several counties of the Commonwealth, and each city not a shire town.

SEC. 4. The duties of the Treasurer of the Commonwealth and his deputy, and the duties and responsibilities of the treasurer of each town, with respect to the keeping, care, verification, and use of the standard weights and measures so furnished, shall be the same with

those established by existing statutes with respect to the standard weights and measures heretofore provided. And it is hereby provided that no shire town in which there may be two or more sealers of weights and measures shall for that reason be required to procure additional sets of the metric weights and measures.

SEC. 5. The deputy and Treasurer shall verify, adjust, and seal all metric weights and measures that may be brought to him for that purpose, and he shall receive a reasonable compensation therefor; and the sealer of weights and measures in each town that shall receive the standard metric weights and measures, as hereinbefore provided, shall verify, adjust, and seal all metric weights and measures that may be brought to him for that purpose from within the county in which such town is situated, and he shall receive a reasonable compensation therefor; but he shall claim no fees for any sealing, verification, or adjustment, for the performance of which he may otherwise receive compensation by salary paid by the town.

SEC. 6. All persons using weights or measures of the metric system for the purpose of selling any goods, wares, merchandise, or other commodities, shall have them adjusted, sealed, and recorded, by some authorized sealer of weights and measures, and shall thereafter be responsible for the correctness and exactness of the same; and no person using illegally or fraudulently the metric weights and measures shall thereby be freed from any liabilities or penalties to which he would have been exposed in case the weights and measures employed had been the ordinary weights and measures heretofore and now in use in this Commonwealth.

Cleopatra's Needle.—This obelisk, of Syenitic granite, sixty-eight and one-half feet long, six feet eleven inches wide on each side of the base, tapering to four feet nine inches near the summit, is 3,300 years old, and was set up by Sesostris in front of the temple at Heliopolis. It was brought to Alexandria by Cleopatra about the year 40, and has been there, standing or lying, upward of 1,800 years. It is of rose-colored stone, and is covered with hieroglyphics. It was presented many years ago by the Pasha of Egypt to the Prince Regent of England, and the British Government accepted the gift, but have never been able to get it transported to London. At length Dr. Erasmus Wilson, a distinguished surgeon of that metropolis, and known as the author of books on skin-diseases, concluded to pay the expenses himself of transporting the great monolith, and bargained with a Mr. Dixon to bring it to England and erect it on the Thames Embankment for £10,000.

The plan proposed for transporting the "Needle" to England is described as follows in *Chambers's Journal:* "The obelisk is to be fixed by cross-divisions or diaphragms of wood in a cylindrical vessel formed of wrought-iron plates. There will be seven diaphragms, and consequently nine water-tight compartments. For safety, the obelisk will be inclosed in wood and well packed, a little below the central level of the vessel, which will be closed at both ends. When completed, with the obelisk inside, the vessel will be about ninety-five feet in length and fifteen feet across. After being rolled into the sea and towed to the harbor, it will be ballasted and be provided with a keel, deck, sail, and rudder. For these operations, man-holes will have been left in the cylinder. These holes will be opened, so that access may be had to all the compartments. There will be no part into which a man may not enter if necessary until the cylinder is finally sealed up for floating. The vessel will be in charge of two or three skilled mariners, for whom a small cabin on deck will be provided. It will be towed the whole way by a steam-tug, the sail being simply for steadying the cylinder." There is likely to be some delay in executing this project, for it is now reported that the Egyptian who owns the sand around the obelisk objects to the removal of the shaft, claiming it as his property.

Education and Crime.—In a recent number of the *Polytechnic Review* is an abstract of a paper on "Useful Education," by Mr. R. Bingham, containing many facts and observations that are worthy of notice in these times of "forcing" in education. Mr. Bingham does not believe that school-education tends to diminish crime. He says that the ratio of crime to population is less in Ireland than in Massachusetts, and that property is more secure in Italy, with its many millions of illiterates, than in the Old Bay State with all its schools. Of the 373 prisoners received last year into the Western Penitentiary of the State of Pennsylvania, 285 had attended public schools, 19 private schools, and 69 had never gone to school. Of the 2,383 prisoners received into the Eastern Penitentiary of the same

State during the ten years ending with 1869, 17.21 per cent. were illiterate, and 81.83 per cent. had never been apprenticed. "All observers will admit," remarks the author, "that there is not as much intelligence and skill working on the farms now as there was twenty years ago. The fears of the farmers were not that their sons would *know* too much, but that they would do too little. It was not book-farming, or wisdom with work, they feared; but making hay in the shade, or farming by the fireside; plucking geese in the courts, preaching for practice, pills for pumpkins, the pen and yard-stick for the plough and harvest-fork. The change has not been from prison to school so much as from honest labor to idleness and crime. Everything else being equal, mental culture raises the standard of morality; but we would choose a community of industrious and illiterate members, rather than one of idle and literary habits, for a high standard of morality."

Latest Phase of the Spontaneous-Generation Controversy.—Dr. Bastian, of London, having submitted to the Paris Academy of Sciences the results of certain experiments which, as he maintains, decisively confirm his theory of spontaneous generation, Pasteur criticised the English investigator's methods and conclusions, and asked for the appointment of a commission to determine on which side the truth lies. At the same time he expressed a wish that Dr. Bastian should in like manner ask the London Royal Society to appoint a similar commission. According to the terms of M. Pasteur's challenge, Dr. Bastian must obtain, in the presence of competent judges, bacteria in sterile urine on the addition of liquor potassæ in suitable quantities, the liquor potassæ being prepared from pure potash with pure water; or, if made from impure materials, it must be submitted to a temperature of 230° for twenty minutes. Dr. Bastian has accepted the challenge, and has applied to the Royal Society for the appointment of the commission. The French commission is already constituted: it consists of Milne-Edwards, Dumas, and Boussingault. The *Lancet* justly complains against this selection, on the ground that all of the three commissioners are more or less strong supporters of Pasteur's view. Their bias must inevitably indispose them toward Bastian's arguments. The *Lancet* asks why Frémy or Trécul, or some other man without bias either way, was not placed on the commission. The Academy has apparently made a mistake in this matter; perhaps when the comments of the *Lancet* are brought to the notice of the members, a change will be made in the commission. The Royal Society has not yet named the members of the English commission.

Action of the Retinal Nerves.—Some years ago, while suffering from indisposition, Prof. Tait observed that, whenever he awoke from a feverish sleep, the flame of a lamp, seen through a ground-glass shade, assumed a deep-red color, the effect lasting about a second. He supposes that the nerve fibrils of the retina also slept, and that, on awaking, the green and violet nerves resumed their functions a little later than the red. This observation of Tait's is recalled by Prof. Ogden N. Rood, in the *American Journal of Science*, who adds an analogous observation of his own, going to show that after nervous shock the green nerves (to adopt the theory of Young) receive their activity later than the red, and probably later than the violet nerves. Having taken chloroform at the hands of a dentist, he observed with surprise, on regaining consciousness, that the operator's face was very red, and the next instant that his hair was of a purplish-red hue. The illusion persisted for a second or two. Prof. Rood then gives an instance of chronic effects of similar character which were observed for a couple of weeks continuously, during convalescence from typhoid fever. In this case white objects appeared of a not very intense orange-yellow; here the activity of the green and yellow nerves was diminished relatively to that of the red.

Food of the Water-Tortoise.—Though proverbial for its sluggishness, the water-tortoise, according to a writer in *Science Gossip*, appears to have a special relish for the natural food of the cat. Keeping a couple of them in an aquarium, but uncertain as to the kind of food best suited to their needs,

this gentleman fed them at first with worms, slugs, and flies, and of the latter they seemed very fond; yet they did not thrive. One morning on entering the room in which their tank was placed, he discovered a sparrow which had got in through an open window, and which in its efforts to escape had fallen into the tank, when the larger tortoise quickly seized it by the leg and drew its head under the water until it was drowned. Two hours afterward nothing remained of the bird but the wing-feathers, and cleanly-picked bones; all the rest of it having been devoured. After this the animals would not touch even flies for nearly a week; but then, on offering them a dead gold-fish about five inches long, they ate it eagerly, leaving nothing but the head and backbone. A week or ten days later, a live mouse was dropped into the tank, and, like the sparrow, this was soon seized by the larger tortoise—by the head instead of the legs—and pulled under the water until drowned. The head was then torn off, the skin turned inside out and rejected, and all the other parts devoured except the bones. This food appeared to agree with them perfectly, and they were afterward supplied with mice, on which they grew rapidly and kept in excellent condition.

Fielding Bradford Meek.—The *American Journal of Science and Arts* for March contains an obituary notice of Fielding Bradford Meek, whose death occurred on December 21st. From it we gather the following particulars relating to the life and labors of that distinguished paleontologist: He was born in Madison, Indiana, on December 10, 1817, and in early manhood chose a mercantile career. Here he was unsuccessful, and in 1848 he became an assistant in the United States Geological Survey of Iowa, Wisconsin, and Minnesota. In 1852 he was assistant to Prof. Hall, at Albany, in the paleontological work of the State of New York. Here he remained until 1858, with the exception of three summers spent on geological surveys of Western States and Territories. In 1858 he went to Washington, and there remained till his death, except while in the field. The invertebrate paleontology of the Rocky Mountain region, as developed by Dr. Hayden's survey, was intrusted to Meek. He also helped to work up the invertebrate paleontology of Illinois, Ohio, California, and sundry Territories surveyed by other expeditions besides Hayden's. Thoroughness, scrupulous exactness, and nice powers of discrimination, are manifested in all his labors. "No one in America," says Dr. C. A. White, the author of the obituary notice from which we quote, "has done more than he to systematize and advance the science to which he devoted his life." His health was always precarious, and for several years before his death he was entirely deaf. He never married, and left no near relatives.

The Electrical Phenomena of the Torpedo.—Marey has lately been engaged in studying the electrical discharges of the torpedo, with the aid of a very delicate electrometer and an inscribing apparatus. His experiments show that, on exciting a nerve of the animal's electrical apparatus, a flow of electricity follows in about one-eightieth of a second, lasting about one-fortieth of a second. The voluntary discharge of the torpedo consists of successive flows of currents, varying, according to temperature, from twenty to one hundred and forty shocks per second; the direction of the currents being from the back to the belly. As the currents continue to flow for a longer time than the intervals between the times of their commencement, it happens that several currents flow simultaneously, and thus the intensity of the discharge is increased by accumulation. The phenomena correspond closely to those of muscular work.

The Appalachian-Mountain Club.—Prof. E. C. Pickering, President of the Appalachian-Mountain Club, in his annual address, congratulates the club on the large attendance of members at the ten meetings so far held, and the interest manifested in the labors of the club. The principal scientific work of the club for the past season was in the direction of topography—collecting all the available measurements from the works of Bond, Lock, Vose, and Hitchcock. A complete map of the White Mountains has been made by Mr. Henck. One of the greatest achievements of the club is the introduc-

tion of Edmands's Topographical Camera, an instrument by means of which mountain profiles may be drawn with great accuracy. The work done by the president himself includes between 6,000 and 7,000 measurements of the horizontal and vertical positions of the mountains. The "Department of Improvements" has constructed a substantial path which makes the peak of Mount Adams easily accessible to any good pedestrian. An excellent camp has been established on Mount Adams, which will doubtless soon be followed by others. The club at present has its headquarters in the Massachusetts Institute of Technology, but this arrangement is only temporary, and it is the intention of the Council, as soon as possible, to hire a room in which to collect a library of books, maps, photographs, and paintings of the mountains. A summer school of topography, under the auspices of the club, and with special reference to State surveys, is in contemplation.

Economy in Stock-Feeding.—We commend to the attention of such of our readers as are farmers a paper by Prof. Samuel W. Johnson, in the *American Journal of Science and Arts* for March, on "The Composition of Maize-Fodder." The paper is extremely valuable, and abounds in practical observations, for two or three of which we make room here. Regarding the influence of age upon the content of albuminoids in forage plants, the author states that quite young meadow-grass as it is found in pasturage contains in its dry matter twenty-four per cent. of albuminoids, cut just before bloom twelve per cent., and at the end of blossoming eight per cent. In case both of maize-fodder and meadow-grass the inferior quality of the older vegetation is compensated by the superior quantity. The author holds that in New England the farmers can raise or buy Indian corn, cotton-seed, meal, and other concentrated foods, and combine them with coarse fodder to make a cattle food equal or superior to the best of hay, at less cost than is involved in feeding the latter. But to throw cured maize-fodder out in the cattle yard, or to feed it in the stall as hay is fed, is highly wasteful. It cannot be fed alone or as an adjunct to hay: to use it profitably it must be finely cut and well mixed or alternated with maize or cotton-seed meal, bran, or some similar material. Maize meal and similar articles contain too much albuminoids, fat, and starch, for healthy and economical cattle food; maize-fodder contains too little of these and too much coarse fibre; the two should be mixed.

Where the Ancients got their Tin.—Shortly before his death, Karl Ernst von Baer contributed to the *Archiv für Anthropologie* a paper entitled "Whence came the Tin for Ancient Bronze?" The subject is one that has long engaged the attention of archæologists, but hitherto the only sources assigned for this tin have been Cornwall and the straits of Malacca. There has, however, been a vague notion that tin may also have been derived from Georgia, Armenia, or Persia. To decide this question, Von Baer addressed an inquiry to M. Semenow, Vice-President of the Russian Geographical Society, who obtained the desired information from a traveler named Ogorodinkow. According to his report, tin occurs and has been worked in two localities in Khorassan. It was the opinion of Von Baer that many of the bronzes of Assyria and Babylonia were made from tin obtained in this region.

NOTES.

The *Christian Union* has begun the publication of a series of articles, by distinguished writers, on "How to spend the Summer." Each writer will speak from personal experience, and, if the articles we have seen are a fair sample of those to come, everybody seeking health or pleasure, either at home or abroad, will be profited by reading them.

Admission to hospital for purposes of clinical instruction has at last been granted to female medical students in London. This removes the only remaining obstacle to a complete medical course for women in England; and the concession came just in time to prevent the break-up of their leading medical school.

During the coming summer a limited number of teachers of mathematics or astronomy will be permitted to spend a portion of their vacation at the Cincinnati Observatory, in the pursuit of studies connected with their special departments of instruction. Particular attention will be paid to the art of computing, in order to give an

insight into the practical application of mathematics to astronomy. Opportunity will also be afforded to learn the use of instruments.

Siegfried Stein advocates the employment of rock-crystal for making normal standards of weight and measure, and other instruments of precision. The advantages of rock-crystal for these purposes consist in its indifference, at common temperature, to the action of acids and bases, or of atmospheric gases or moisture.

A new method of cleaning the skeletons of small animals, by utilizing the enormous appetites of tadpoles, is described in the *English Mechanic*. M. Lareste, the discoverer, has found that the tadpoles may be quickly habituated to a meat-diet, and that they rapidly denude the bones, when the carcass, previously skinned, is presented to them in water, kept in a warm and somewhat darkened place.

The syllabus of a course of lectures on American prehistoric archæology, to be delivered before the College of Fine Arts of Syracuse University, during the spring term of 1877, by Dr. Wills De Hass, comprises such topics as "Discovery and Settlement of the Atlantic Coast," "Lost Semi-Civilization of the Mississippi Valley," "Tumular Monuments," "Mural Works," "Art-Remains in Stone," "Rock Sculpture," "Art-Remains in Pottery, also in Bone, Shell, and Metal," "Monumental and Art Remains found in the Lake-Regions," "Origin and Antiquity of the Mound-Builders," etc.

A preparation of tungstate of soda and starch has been highly recommended for rendering muslin dresses uninflammable. At a recent trial of it in London, the dress fortunately being placed on a dummy, the saturated fabric readily took fire, blazed up, and was quickly consumed.

The *Sanitary Record* laments that they have no cremation-furnace in London, considering it a breach of hospitality that they cannot offer the facilities for fire-burial to their Indian guests who are so unfortunate as to die in England.

A course of lectures on the elementary principles of stock-breeding was delivered during the spring by Prof. William H. Brewer, at the Scientific School of Yale College, which it is to be hoped will before long appear in book-form. The topics discussed in these lectures are: "Heredity," "Atavism," "Close-Breeding," "Crossing," "Relations of Animals to their Surroundings," "Variation," "Relations between Heredity and Variation," "Breeding to Points," "Limitations of Breeding to Points," "Prenatal Influences," "Relative Influence of Sire and Dam," "Crossing for Immediate Special Uses," and "Profitable Adaptation of Breeds to Special Localities and Conditions."

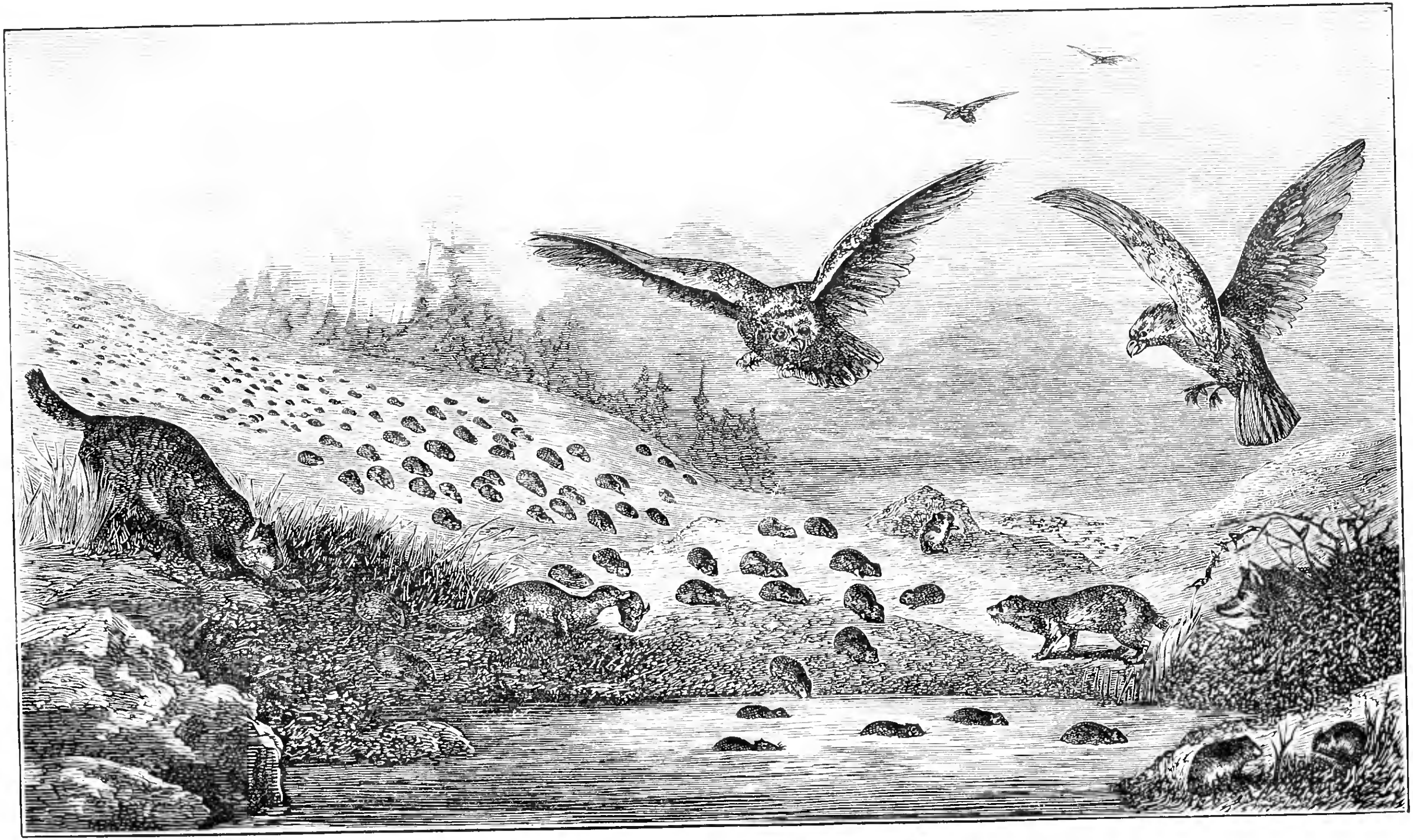
Dr. Philip P. Carpenter, brother of the celebrated physiologist, William B. Carpenter, died in Montreal, May 24th. He was born in Bristol, England, in 1819, was educated at the University of Edinburgh, studied theology first, and preached awhile, and then gave himself up to natural history. He devoted himself to the mollusca, and gave a magnificent collection of shells to the British Museum. In 1859 he came to this country, and, selecting Montreal as his place of residence, went on with his scientific work till the failure of an English bank swept away his property, and he then took to teaching and sanitary reform. He gave a large collection of shells to McGill College, and was known as one of the best authorities on the classification of mollusca. He was a clever writer, a forcible speaker, and a man of refined Christian character.

Prof. E. S. Morse, of Salem, sailed from San Francisco, June 1st, for Japan, whither he goes on a scientific mission of his own. He will spend the summer months in pursuing his favorite studies of natural history amid Japanese resources, and will devote especial attention to the animals of the coast, dredging a good deal, and carrying on the investigation of the Brachiopoda, which has long been his favorite line of inquiry. He will also make the trip subservient to gathering fresh materials for illustrating the "Second Book of Zoölogy," a text-book which he has begun to prepare. Prof. Morse will also, no doubt, gain much curious and interesting information to enrich the lectures which he will return in time to deliver before the lyceums next season.

Broca assigns to the terms *anthropology*, *ethnology*, and *ethnography*, the following distinctive significations: anthropology is the general study of man or of the entire human species; ethnology is the study of the natural divisions of this group, which are generally known as the races of man; ethnography is the artificial subdivision of races into peoples.

Twenty years ago, according to Dr. Siemens, it required over five tons of coal to make a ton of iron rails. Now, a ton of steel rails may be produced from the ore with half that quantity of coal.

The *Pharmacist* quotes the statement from a foreign journal that chemically pure glycerine, when taken in large quantities, exerts a poisonous effect on the system, comparable, within certain limits, to that produced by alcohol.



LEMMINGS IN MIGRATION.—See page 408.

THE

POPULAR SCIENCE MONTHLY.

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THE CLIMATIC INFLUENCE OF VEGETATION.—A PLEA FOR OUR FORESTS.

By F. L. OSWALD, M. D.

"AS a fellow-Unitarian, I feel sorry for the Turks," Dr. Schliemann writes from Salonica, "but, as a respecter of God's physical laws, I must own that they deserve their fate. Men who for twenty generations have proved themselves tree-destroyers on principle, have no right to complain if the world rises against them."

It would be well for the world if for the last twenty generations the Turks had been the only "tree-destroyers on principle." Since the advent of the Christian religion, the physical history of our planet records the steady growth of a desert, which made its first appearance on the dry table-land of Southern Syria, and gradually spreading eastward down the Euphrates toward Afghanistan, and westward along both shores of the Mediterranean, now extends from Eastern Persia to the western extremity of Portugal, and sends its harbingers into Southern France and the southeastern provinces of European Russia. Like a virulent cancer, the azoic sand-drifts of the Moab Desert have eaten their way into Southern Europe and Northern Africa, and dried up the life-springs of districts which beyond all dispute were once the garden-regions of this earth.

Prince de Ligne, countryman and contemporary of Maria Theresa, wrote an essay "On the Location of the Earthly Paradise," and, after some reflections on the hygienic influence of different climates, calls attention to the fact that "paradise-traditions, in locating the garden of Eden, differ only in regard to longitude, but not to latitude. The latitude keeps always near the *snow-boundary*, a line just south of the regions where snow may fall, but will not stay on the ground. It passes through Thibet, Cashmere, Northern Persia, and Asia Minor,

and reaches the meridian of Europe near the centre of the Mediterranean." The nations that "celebrated life as a festival" have lived along this line, and we may doubt if in the most favored regions of the New World human industry, with all the aids of modern science, will ever reunite the opportunities of happiness which Nature once lavished on lands that now entail only misery on their cultivators. All over Spain and Portugal, Southern Italy, Greece, Turkey, Asia Minor, Persia, and Western Afghanistan, and throughout Northern Africa, from Morocco to the valley of the Nile, the aridity of the soil makes the struggle for existence so hard that to the vast majority of the inhabitants life from a blessing has been converted into a curse.

Southern Spain, from Gibraltar to the head-waters of the Tagus, maintains now only about one-tenth of its former population, Greece about one-twentieth. As late as A. D. 670, a good while after the rise of the Mohammedan power, the country now known as Tripoli, and distinct from the Sahara only through the elevation of its mountains, was the seat of eighty-five Christian bishops, and had a population of 6,000,000, of which number three-quarters of one per cent. are now left! The climate which, according to authentic description, must once have resembled that of our Southern Alleghanies, is now so nearly intolerable that even the inhumanity of an African despot forbears to exact open-air labor from 9 A. M. to 5 P. M. Steamboats that pass near the Tripolitan coast in summer, on their way from Genoa to Cairo, have to keep up a continual shower of artificial rain to save their deck-hands from being overcome by the furnace-air that breathes from the barren hills of the opposite coast. The rivers of some of these countries have shrunk to the size of their former tributaries, and from Gibraltar to Samarcand the annual rainfall has decreased till failure of crops has become a chronic complaint.

And all this change is due to the insane destruction of forests. The great Caucasian *sylvania* that once adorned the birth-land of the white race from the Western Pyrenees to the foot-hills of the Himalayas has disappeared; of the forest-area of Italy and Spain, in the days of the elder Pliny, about two acres in a hundred are left; in Greece, hardly one. But even the nakedness of the most sterile tracts of Southern Europe is exceeded by the utter desolation of the Ottoman provinces. If there was not evidence that a great part of the ruin had been accomplished before the fall of the Byzantine Empire, the Turks would really seem to have been "tree-destroyers on principle." In the recesses of the Taurus range and the inaccessible heights of those

> ". . . . mountains that distill
> Indus and Oxus from their icy caves"—

a few remnants of wood have survived the general devastation, but throughout the lowlands, from Bokhara to the Golden Horn, not a stick or bush can grow up before the wood-famine of the wretched

population lays violent hands upon it. In Northern Africa, Dalmatia, and the larger islands of the Grecian Archipelago, the same evil has made terrible advances. The Mediterranean Sea, once a forest-lake of paradise, is now a dead sea, surrounded by dusty and burning coasts, often for hundreds of miles without a vestige of organic life.

The present appearance of the Troad, the neighborhood of Lake Tiberias, the valley of the Euphrates, and other districts that were once teeming with population, can actually make us doubt if there ever was such a thing as an original desert. On the plateau of Sidi-Belbez, in the very centre of the Sahara, Champollion traced the course of former rivers and creeks by the depressions in the soil and the shape of the smooth-washed pebbles. He also found tree-stumps, now almost petrified, and covered by a six-foot stratum of burning sand.

"And so the astounding truth dawns upon us," he says, "that this desert may once have been a region of groves and fountains, and the abode of happy millions. Is there any crime against Nature which draws down a more terrible curse than that of stripping our Mother Earth of her sylvan covering? The hand of *man* has produced this desert, and I verily believe every other desert on the surface of this earth. Earth was Eden once, and our misery is the punishment of our sins against the world of plants. *The burning sun of the desert is the angel with the flaming sword who stands between us and paradise.*"

That the inhabitants of these artificial deserts have failed to recognize the cause of their misery implies a degree of infatuation and mental blindness which may appear even more incredible to future generations than the thousand years' belief in witchcraft and the patient submission of 80,000,000 able-bodied men to a juggler-guild of priests. Even frogs and fishes become uneasy if the plug-hole of their tank is opened and their life-element begins to ebb away; and it should be supposed that, without any scientific aids to reflection, the sheer instinct of self-preservation could have suggested the simple remedy before the evil attained its present proportions.

But this blindness of the Latin races and the devotees of Islam, if not justified, is at least partly explained by the fatalism of their religion. Their belief in supernatural agencies, and a meddlesome Providence that ruled the world *in spite of man*, naturally produced indifference to all physical sciences whatever. The three Semitic religions have done more to divorce man from Nature than all his inborn vices and the "necessary decay of civilized races" that is so often preferred as an explanation. "Though our mortal eyes have failed to penetrate the depths of heaven," says Erasmus, "we have succeeded in losing sight of our own earth." If this earth was a vale of tears, and heaven our proper home, all attention to earthly affairs seemed so much lost time, and in the souls of men who were taught to consider their natural feelings as antagonistic to the will of God the warning voice of instinct was raised in vain.

Much more unaccountable seems our own indifference to the disappearance of our forests, since our science has demonstrated to the satisfaction of all rational and semi-rational beings—including some very conservative rulers of Western Europe—that an animal flayed, or a tree stripped of its bark, does not perish more surely than a land deprived of its trees.

The Duke of Burgundy's rule, "One-third to the hunter, two-thirds to the husbandman," expresses about the most desirable proportion of woodlands and cultivated fields. In a country blessed with such a plethora of woods as the United States between the Atlantic and the valley of the Mississippi could boast of less than a hundred years ago, the work of "clearing" could therefore be pursued within very liberal limits, not only without injury, but with positive benefit to the climate, inasmuch as it would counteract excess of moisture and miasmatic tendencies. But in some of our Southern and Central States this limit has already been passed. The States of Ohio and Indiana, and the southern parts of Kentucky and Michigan, so recently a part of the great East-American forest, have even now a greater percentage of treeless area than Austria and the North-German Empire, that have been settled and cultivated for upward of a thousand years. The northern borders of Ohio are kept comparatively fertile by the neighborhood of the great lakes, but the central regions, and many of the river-counties, begin to suffer from drought, and see their springs fail in every summer. The "Blue-Grass" region of Kentucky, once the pride of the West, has now districts of such a barren and arid nature that their stock-farmers are moving toward the Cumberland Mountains, because the creeks and old springs dried up, and their wells became too low to furnish water for their cattle.

Wherever tobacco and cotton are cultivated, the work of ruin has made rapid advances, and in all the southeastern counties of Virginia and North Carolina, and throughout Mississippi, Alabama, Georgia, and South Carolina, the traveler may ride for hours without seeing more than four or five trees in a group; droughts are becoming more and more frequent, and the locust, that ominous pioneer of the desert, has made its appearance.

The climatic influence of arboreal vegetation must be more generally understood, before such legislative measures as the importance of the subject demands, can be hoped for. In the economy of Nature forests perform innumerable functions which no artificial contrivance can imitate, and of which the following are only the most important:

Woods, in the first place, are the water-reservoirs of Nature, and hold in the network of their roots and their moss-carpet the moisture which is intended to supply our water-courses in the season of midsummer heat. One acre of full-grown beech-trees absorbs and dispenses as much humidity as twenty acres of grape-vines and tobacco, and more than two hundred acres of cereals.

Forests *produce* rain. Under the influence of vertical sun-rays trees exhale the aqueous vapors which their leaves have absorbed from the atmosphere, and in contact with the night-air or any stray current of lower temperature, these vapors discharge rain-showers even in mid-summer, and at a great distance from the sea.

By moistening the air woodlands also moderate the extremes of heat and cold. It is seen on the sea-shore how beneficently humidity operates in allaying the severity of winter, and in summer the evaporation of dew and rain gives us cool breezes when they are most needed. By the extirpation of forests the climate of the entire *Orbis Romanus* has been changed from the summer temperature of West Virginia to the furnace-heat of New Mexico and Arizona.

Besides this, the forest by shade in summer and fuel in winter protects us directly against the vicissitudes of temperature, and at the foot of high mountains interposes a mechanical barrier between the valleys and avalanches in the north, and floods in the south. The water-torrents, which not only flood and damage the lowlands, but carry their fertile soil away, are imbibed or detained by extensive forests. Joseph II. of Austria was right to attach heavy penalties to the destruction of the "Bannwälder," the woods on the Alpine slopes, that protect the valleys from avalanches, and to propose that in wars, even *à l'outrance*, the trees of a country should be spared by international agreement.

Our woods are also the home and shelter of those best friends of man, the insectivorous birds. A country destitute of trees is avoided by birds, and left to the ravages of locusts and other insects, which, as we saw on our own continent, always attack the barren and naked districts. Our locust-swarms devastated the "Great West," i. e., the treeless expanse between the Mississippi and the Rocky Mountains, but spared the woodlands of the Alleghanies and the timber-regions of the Pacific slope.

The exhilarating influence of a woodland excursion is not altogether due to scenic effects and imagination. Forests exhale oxygen, the life-air of flames and animal lungs, and absorb or neutralize a variety of noxious gases. Scirrhous affections of the skin and other diseases disappear under the disinfecting influence of forest-air. Dr. Brehm observes that ophthalmia and leprosy, which have become hereditary diseases, not only in the valley of the Nile, but also on the table-lands of Barca and Tripoli, are utterly unknown in the well-timbered valley of Abyssinia, though the Abyssinians live more than a hundred geographical miles *nearer* to the equator than their afflicted neighbors.

The traditions of the "blessed islands of the West," the "Garden of the Hesperides," probably referred to Madeira and the Cape-Verde Archipelago, which, according to De Gama's description, must have come nearer to our idea of terrestrial paradise than any other region

of this earth. "The ills that flesh here is heir to," he says, "are only three: wounds, the effects of poison, and decrepitude—the latter rarely makes its appearance before the completion of the ninetieth year." Since the Portuguese have felled their glorious forests for the sake of *madeira* (building-material), these islands have become hot-beds of disease.

The valley of the Guadalquivir, as late as a century before the discovery of America, supported a population of 7,000,000 of probably the healthiest and happiest men of Southern Europe. Since the live-oak and chestnut groves of the surrounding heights have disappeared this population has shrunk to a million and a quarter of sickly wretches, who depend for their sustenance on the scant produce of sandy barrens that become sandier and drier from year to year.

It would be exaggeration to say that the barrenness of a treeless country is an evil without remedy. Nature is always ready to assist in any work of regeneration, and there is no desert so void and naked that it might not be reclaimed in the course of half a century. The Khédive of Egypt has wrested land from the sand-wastes as the Hollanders win it from the sea, and by a cheaper process than the building of extensive dikes. By planting date-palms and olive-trees, Egypt has added many hundred square miles to her arable surface, and, as Baker-Pasha assures us, her *annual rainfall* has almost doubled. Between Karnak and Soodan the rain-gauge shows now a yearly average of sixteen inches, where nine inches was the maximum before 1820. And not only the limits of these tree-plantations, but also the adjoining districts, have been benefited; on the table-land of Wady-Halfa the present temperature is not nearly as oppressive as it was within the memory of men now living, and currant-bushes and wild-mulberries have sprung up where they never grew before. In France, too, the Government has reclaimed the *Landes*, a sandy steppe on the southwestern coast, by planting willows and bay-trees; and even Algeria has been improved by the persistent tree-culture of the French colonists.

But how slow and laborious is this work of restoration, and how easily might we forestall its necessity if we would begin in time! A legislative act to protect the woods of all the upper ridges in hill-countries, and of a certain percentage of acres, say fifteen in a hundred, in the plains, would be an effectual guarantee against evils which otherwise will assuredly overtake us, and speedier than Europe, on account of the compact shape of our continent, that deprives us of the advantages of a marine climate.

Let us remember that the aphorism of the greatest physician of modern times applies to other organisms as well as to the human body. "Timely prevention," said Dr. Radcliffe, "not only saves us from diseases, but from those greater evils—*the remedies*."

EDUCATION AS A SCIENCE.

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III.

In preceding articles,[1] the psychological bearings of Education were entered upon; and two out of the three primary functions of the intellect were considered. There remained the power named—

Similarity or Agreement.—It is neither an inapt nor a strained comparison to call this power the law of gravitation of the intellectual world. As regards education, it has an importance coequal with the plastic force that is expressed by retentiveness or memory. The methods to be pursued in attaining the commanding heights of general knowledge are framed by the circumstances attending the detection of like in the midst of unlike.

With all the variety that there is in the world of our experience, a variety appealing to our consciousness of difference, there is also great repetition, sameness, or unity. There are many shades of color, as distinguished by the discriminative sensibility of the eye; yet the same shade often recurs. There are many varieties of form—the round, the square, the spiral, etc.—and we discriminate them when they are contrasted; while the same form starts up again and again. At first sight, this would appear to mean nothing at all; the great matter would appear to be to avoid confounding differences—blue with violet, a circle with an oval; when blue recurs, we simply treat it as we did at first.

The remark is too hasty, and overlooks a vital consideration. What raises the principle of similarity to its commanding height is the accompaniment of *diversity*. The round form first discerned in a ring or halfpenny recurs in the full moon, where the adjuncts are totally different and need to be felt as different. In spite of these disturbing accompaniments, it is important to feel the agreement on the single circumstance called the round form.

When an impression made in one situation is repeated in an altered situation, the new experience reminds us of the old, notwithstanding the diversity; this reminder may be described as a new kind of shock, or awakened consciousness, called the shock or flash of identity in the midst of difference. A piece of coal and a piece of wood differ, and are at first looked upon as differing. Put into the fire, they both blaze up, give heat, and are consumed: here is a shock of agreement which becomes an abiding impression in connection with

[1] *See* Popular Science Monthly for February and March, 1877.

these two things. Of such shocks is made up one-half of what we term knowledge.

Whenever there is a difference it should be felt by us; and so wherever there is an agreement it should be felt. To overlook either the one or the other is stupidity of mind. Our education marches in both lines; and, in so far as we are helped by the schoolmaster, we should be helped in both. The artifices that promote discrimination, and the influences that thwart it, have been already considered; and many of the observations apply also to agreement. In the identifying of like in the midst of unlike, there are cases that are easy; and there are cases that the unassisted mind fails to perceive.

1. We must repeat, with reference to the delicate perception of Agreements, the antithesis of the intellectual and the emotional outgoings. It is in the stillness of the emotions that the higher intellectual exercises are possible. This circumstance should operate as a warning against the too frequent recourse to pains and penalties, as well as against pleasurable and other excitement. But a more specific application remains.

We may at once face the problem of general knowledge. The most troublesome half of the education of the intellect is the getting possession of generalities. A general fact, notion, or truth, is a fact recurring under various circumstances or accompaniments: "heat" is the name for such a generality; there are many individual facts greatly differing among themselves, but all agreeing in the impression called heat—the sun, a fire, a lamp, a living animal. The intellect discerns, or is struck with, the agreement, notwithstanding the differences; and in this discernment arrives at a general idea.

Now the grand stumbling-block in the way of the generalizing impetus is the presence of the individual differences. These may be small and insignificant; in comparing fires with one another, the agreement is striking, while the differences between one fire and another, in size, or intensity, or fuel, do not divert the attention from their agreement. But the discerning of sameness in the sun's ray and in a fermenting dung-heap is thwarted by the extraordinary disparity; and this conflict between the sameness and the difference operates widely and retards the discovery of the most important truths.

2. The device of *juxtaposition* applies to the expounding of agreement, no less than of difference. We can arrange the several agreeing facts in such a way that the agreement is more easily seen. The effect is gained partly by closeness, as in the case of differences, and partly by a symmetrical contact, as when we compare the two hands by placing them finger to finger, and thumb to thumb. Such symmetrical comparisons bring to view, in the same act, agreement and difference. The method reaches far and wide, and is one of the most powerful artificial aids to the imparting knowledge.

3. The *cumulation* of the instances is essential to the driving home of a generality. A continuous, undistracted iteration of the point of agreement is the only way to produce an adequate impression of a great general idea. I cannot now consider the various obstacles encountered in this attempt, nor explain how seldom it can be adhered to in the highest examples. It must suffice to remark that the interest special to the individual examples is perpetually carrying off the attention; and pupil and master are both liable to be turned aside by the seduction.

There is another aspect of the power of similarity, under which it is a valuable aid to memory or retention. When we have to learn an exercise absolutely new, we must ingrain every step by the plastic adhesiveness of the brain, and must give time and opportunity for the adhesive links to be matured. But when we come to an exercise containing parts already acquired by the plastic operation, we are saved the labor of forging fresh links as regards these, and need only to master what is new to us. When we have known all about one plant, we can easily learn the other plants of the same species or genus; we need only to master the points of variety.

The bearing of this circumstance on mental growth must be apparent at once. After a certain number of acquirements in the various regions of study—manual art, language, visible pictures—nothing that occurs is absolutely new; the amount of novel matter is continually decreasing as our knowledge increases. Our adhesive faculty is not improving as we grow in years; very much the contrary: but our facility in taking in new knowledge improves steadily; the fact being that the knowledge is so little new that the forging of fresh adhesions is reduced to a very limited compass. The most original air of music that the most original genius could compose would be very soon learned by an instructed musician.

In the practice of the schoolmaster's art, this great fact will be perpetually manifesting itself. The operation can be aided and guided in those cases where the agreement really existing is not felt. It is one of the teaching arts to make the pupils see the old in the new, as far as the agreement reaches; and to pose them upon this very circumstance. The obstacles are the very same as already described, and the means of overcoming them the same. Orderly juxtaposition is requsite for matters of complexity; and we may have also to counterwork the attractions of individuality.

Constructiveness.—In many parts of our education, the stress lies not in simple memory, or the tenacious holding of what has been presented to the mind, but in making us perform some new operation, something that we were previously unable to do. Such are the first stages of our instruction in speaking, in writing, and in all the mechanical or manual arts. So also in the higher intellectual processes, as in the imagining of what we have not seen. I do not go so far as

to include invention or discovery; the culture of the creative faculty is not comprised in the present discussion.

The psychology of constructiveness is remarkably simple. There are certain primary conditions that run through all the cases; and it is by paying due respect to these conditions that we can, as teachers, render every possible assistance to the struggling pupils.

1. The constructive process supposes *something to construct from;* some powers already possessed that can be exercised, directed, and combined, in a new manner. We must walk before beginning to dance; we must articulate simple sounds before we can articulate words; we must draw straight strokes and pot-hooks before we can form letters; we must conceive trees and shrubs, flowers and grassy plots, before we can conceive a garden.

The practical inference is no less obvious and irresistible; it is one that covers the whole field of education, and could never be entirely neglected, although it has certainly never been fully carried out. Before entering on a new exercise, we must first be led up to it by mastering the preliminary or preparatory exercises. Teachers are compelled by their failures to attend to this fact in the more palpable exercises, as speaking and writing. They lose sight of it, when the succession of stages is too subtile for their apprehension, as in the understanding of scientific doctrines.

2. In aiming at a new construction, *we must clearly conceive what is aimed at;* we must have the means of judging whether or not our tentatives are successful. The child in writing has the copy-lines before it; the man in the ranks sees the fugleman, or hears the approving or disapproving voice of the drill-sergeant. Where we have a very distinct and intelligible model before us, we are in a fair way to succeed; in proportion as the ideal is dim and wavering, we stagger and miscarry. When we depend upon a teacher's expressed approval of our effort, it behooves him to be very consistent, as well as very sound, in his judgment; should he be one thing to-day, and another thing to-morrow, we are unhinged and undone.

It is a defect pertaining to all models that they contain individual peculiarities mixed up with the ideal intention. We carry away with us from every instructor touches of mannerism, and the worst of it is that some learners catch nothing but the mannerism; this being generally easier to fall into than the essential merits of the teaching. There is no remedy here except the comparison of several good models; as the ship-captain carries with him a number of chronometers.

In following an unapproachable original, as in learning to write from copperplate lines, we need a second judgment to inform us whether our deviations are serious and fundamental, or are venial and unavoidable. The good tact of our instructor is here put to the test; he may make our path like the shining light that shineth more and more, or he may leave us in hopeless perplexity. To point out to us

where, how, and why, we are wrong, is the teacher's most indispensable function.

3. The only mode of arriving at a new constructive combination is *to try and try again.* The will initiates some movements; these are found not to answer, and are suppressed; others are tried, and so on, until the requisite combination has been struck out. The way to new powers is by trial and error. According as the first and second conditions above given are realized, the unsuccessful trials are fewer. If we have been well led up to the combination required, and if we have before us a very clear idea of what is to be done, we do not need many tentatives; the prompt suppression of the wrong movements ultimately lands us in the right.

The mastering of a new manual combination—as in writing, in learning to swim, in the mechanical arts—is a very trying moment to the human powers; success involves all those favorable circumstances indicated in discussing the retentive or receptive faculty. Vigor, freshness, freedom from distraction, no strong or extraneous emotions, motives to succeed—are all most desirable in realizing a difficult combination. Fatigue, fear, flurry, or other wasting excitement, does away with the chances of success.

Very often we have to give up the attempt for a time; yet the ineffectual struggles are not entirely lost. We have at least learned to avoid a certain number of positions, and have narrowed the round of tentatives for the next occasion. If, after two or three repetitions, with rest-intervals, the desired combination does not emerge, it is a proof that some preparatory movement is wanting, and we should be made to retrace the approaches. Perhaps we may have learned the prerequisite movements in a way, but not with sufficient firmness and certainty for securing their being performed in combination.

ALTERNATION AND REMISSION OF ACTIVITY.—In the accustomed routine of education, a number of separate studies and acquirements are prosecuted together; so that, for each day, a pupil may have to engage in as many as three, four, or more, different kinds of lessons.

The principles that guide the alternation and remission of our modes of exercise and application are apparently these:

1. Sleep is the only entire and absolute cessation of the mental and bodily expenditure; and perfect or dreamless sleep is the greatest cessation of all. Whatever shortens the due allowance of sleep, renders it fitful and disturbed, or promotes dreaming, is so much force wasted.

In the waking hours, there may be cessation from a given exercise, with more or less of inaction over the whole system. The greatest diversion of the working forces is made by our meals; during these the trains of thought are changed, while the body is rested.

Bodily or muscular exercise, when alternated with sedentary mental labor, is really a mode of remission accompanied with an expenditure requisite to redress the balance of the physical functions. The

blood has unduly flowed to the brain; muscular exercise draws it off. The oxidation of the tissues has been retarded; muscular exercise is the most direct mode of increasing it. But definite observations teach us that these two beneficial effects are arrested at the fatigue-point; so that the exercise at last contributes not to the refreshment, but to the further exhaustion of the system.

2. The real point before us is, What do we gain by dropping one form of activity and taking up another? This involves a variety of considerations.

It is clear that the first exercise must not have been pushed so far as to induce general exhaustion. The raw recruit, at the end of his morning drill, is not in a good state to improve his arithmetic in the military schoolroom. The musical training for the stage is at times so severe as to preclude every other study. The importance of a particular training may be such that we desire for it the whole available plasticity of the system.

It is only another form of exhaustion when the currents of the brain continue in their set channels and refuse any proposed diversion.

There are certain stages in every new and difficult study, wherein it might be well to concentrate for a time the highest energy of the day. Generally, it is at the commencement; but whatever be the point of special difficulty, there might be a remission of all other serious or arduous studies, till this is got over. Not that we need actually to lay aside everything else; but there are, in most studies, many long tracts where we seem in point of form to be moving on, but are really repeating substantially the same familiar efforts. It would be a felicitous ideal adjustment, if the moments of strain in one of the parallel courses were to coincide with the moments of ease in the rest.

Hardly any kind of study or exercise is so complicated and many-sided as to press alike upon all the energies of the system; hence there is an obvious propriety in making such variations as would leave unused as few of our faculties as possible. This principle necessarily applies to every mental process—acquirement, production, and enjoyment. The working out of the principle supposes that we are not led away by the mere semblance of variety.

Let us endeavor to assign the differences of subject that afford relief by transition.

There are many kinds of change that are merely another name for simple remission of the intellectual strain. When a severe and difficult exercise is exchanged for an easy one, the agreeable effect is due not to what we engage in, but to what we are relieved from. For letting down the strain of the faculties, it is sometimes better to take up a light occupation for a time than to be totally idle.

The exchange of study for sport has the twofold advantage of muscular exercise and agreeable play. To pass from anything that

is simply laborious to the indulgence of a taste or liking, is the fruition of life. To emerge from constraint to liberty, from the dark to the light, from monotony to variety, from giving to receiving, is the exchanging of pain for pleasure. This, which is the substantial reward of labor, is also the condition of renovating the powers for further labor and endurance.

To come closer to the difficulty in hand. The kind of change that may take place within the field of study itself, and that may operate both as a relief from strain and as the reclamation of waste ground, is best exemplified in such matters as these: In the act of learning generally there is a twofold attitude—observing what is to be done, and doing it. In verbal exercises, we first listen and then repeat; in handicraft, we look at the model, and then reproduce it. Now, the proportioning of the two attitudes is a matter of economical adjustment. If we are kept too long on the observing stretch, we lose the energy for acting; not to mention that more has been given us than we are able to realize. On the other hand, we should observe long enough to be quite saturated with the impression; we should have enough given us to be worthy of our reproducing energy. Any one working from a model at command learns the suitable proportion between observing and doing. The living teacher may err on either side. He may give too much at one dose; this is the common error. He may also dole out insignificantly small portions, which do not evoke the sense of power in the pupils.

When an arduous combination is once struck out, the worst is over, but the acquisition is not completed. There is the further stage of repetition and practice, to give facility, and insure permanence. This is comparatively easy. It is the occupation of the soldier after his first year. There is a plastic process still going on, but it is not the same draft upon the forces as the original struggles. At this stage, other acquirements are possible, and should be made. Now, in the course of training, it is a relief to pass from the exercises that are entirely new and strange, to those that have been practised and need only to be continued and confirmed.

Before considering the alternations of departments of acquisition, we may advert to the two different intellectual energies called, respectively, Memory and Judgment. These are in every way distinct, and in passing from the one to the other there is a real, and not merely an apparent, transition. Memory is nearly identical with the retentive, adhesive, or plastic faculty, which I have assumed to be perhaps the most costly employment of the powers of the mind and brain. Judgment, again, may be simply an exercise of discrimination; it may also involve similarity and identification; it may further contain a constructive operation. It is the aspect of our intellectual power that turns to account our existing impressions, as contrasted with the power that adds to our accumulated stores. The most de-

lightful and fructifying of all the intellectual energies is the power of similarity and agreement, by which we rise from the individual to the general, trace sameness in diversity, and master, instead of being mastered by, the multiplicity of Nature.

Much more would be necessary to exhaust the nature of the opposition between exercises of memory and exercises of judgment. Language and science approximately represent the contrast, although language does not exclude judgment, and science demands memory. But, in the one region, mere adhesion is in the ascendant, and, in the other, the detection of similarity in diversity is the leading circumstance. There is thus a real transition, and change of strain, in passing from the one class of studies to the other; the only qualifying circumstance is that in early years, routine adhesion plays the greatest part—being, in fact, easier than the other line of exertion, for reasons that can be divined.

We can now see what are the departments that constitute the most effective transitions or diversions, whereby relief may be gained at one point, and acquirement pushed at some other. In the muscular acquirements, we have several distinct regions—the body generally, the hand in particular, the voice (articulate), and the voice (musical). To pass from one of these to the other is almost a total change. Then, as to the sense engaged, we may alternate between the eye and the ear, making another complete transition. Further, each of the sense-organs has distinguishable susceptibilities, as color and form to the eye, articulation and music to the ear.

Another effective transition is from books or spoken teaching to concrete objects as set forth in the sciences of observation and experiment. The change is nearly the same as from an abstract subject like mathematics to one of the concrete and experimental sciences, as botany and chemistry. A still further change is from the world of matter to the world of mind, but this is liable to assume false and delusive appearances.

It has been well remarked that arithmetic is an effective transition from reading and writing. The whole strain and attitude of the mind are entirely different, when the pupil sets to perform sums after a reading-lesson. The mathematical sciences are naturally deemed the driest and hardest of occupations to the average mind; yet there may be occupations such as to make them an acceptable diversion. I have known clergymen whose relaxation from clerical duty consisted in algebraical and geometrical problems.

The fine-art acquisitions introduce an agreeable variety, partly by bringing distinctive organs into play, and partly by evoking a pleasurable interest that enters little, if at all, into other studies. The more genial part of moral training has a relationship to art. The severer exercises are a painful necessity, and not an agreeable transition from anything.

The introduction of narratives, stirring incidents, and topics of human interest generally, is chiefly a mode of pleasurable recreation. If taken in any other view, it falls under some of the leading studies, and engages the memory, the judgment, or the constructive power, and must be estimated accordingly.

Bodily training, fine art (itself an aggregate of alternations), language, science, do not exhaust all the varieties of acquirement, but they indicate the chief departments whose alternation gives relief to the mental strain, and economizes power in the whole. Under these, as already hinted, there are variations of attitude and exercise; from listening to repeating, from learning a rule, to the application of it in new cases, from knowledge generally to practice.

The transition from one language to another, being a variation in the nature of the impressions, is a relief of an inferior kind, yet real. It is the more so, if we are not engaged in parallel exercises; learning strings of Latin words in the morning, and of German in the evening, does not constitute any relief.

From one science to another, the transition may be great, as already shown, or it may be small. From botany to zoölogy affords a transition of material, with similarity in form. Pure and mixed mathematics are the very same thing. The change from algebra to geometry is but slightly refreshing; from geometry to trigonometry, and geometrical conic sections, is no relief to any faculty.

There are minor incidents of relief and alternation that are not to be despised. Passing from one master to another (both being supposed competent) is a very sensible and grateful change; even the change of room, of seat, of posture, is an antidote against weariness, and helps us in making a fresh start. The jaded student relishes a change of books even in the same subject, the alteration from solitude to company.

Some subjects are in themselves so mixed that they would appear to contain the elements of a sufficiently various occupation of the mind; such are geography, history, and what is called literature, when studied both for expression and for subject-matter. This variety, however, is not altogether a desirable thing. The analytic branch of the science of education would have to resolve those aggregates into their constituent parts, and consider not only their respective contributions to our mental culture, but also the advantages and disadvantages attending the mixture.

Culture of the Emotions.—The laws attainable in the departments of emotion and volition are the immediate prelude to moral education, in which all the highest difficulties culminate. There are emotional and volitional forces prior to any cultivation, and there are new forces that arise through cultivation; yet from the vagueness attaching to the measured intensity of feelings and emotions, it is not easy to value the separate results.

The general laws of retentiveness equally apply to emotional growths. There must be repetition and concentration of mind to bring about a mental association of pleasure or of pain with any object. But there are peculiarities in the case such as to demand for it a supplementary treatment. Perhaps the best way of bringing out the points is to indicate the modes or species of growths, coming under emotion and volition, that most obtrude themselves upon the notice of the educationist.

I. We may quote first the associations of pleasure and pain with the various things that have been present to us, during our experiences of delight and suffering. It is well known that we contract pleasurable regards toward things originally indifferent that have been often present to us in happy moments. Local associations are among the most familiar examples; if our life is joyous, we go on increasing our attachments to our permanent home and neighborhood; we are severely tried when we have to migrate; and one of our holiday delights is to revisit the scenes of former pleasures. A second class of acquired feelings includes the associations with such objects as have been the instruments of our avocations, tastes, and pursuits. The furnishings of our home, our tools, weapons, curiosities, collections, books, pictures—all contract a glow of associated feeling, that helps to palliate the dullness of life. The essence of affection, as distinguished from emotion, is understood to be the confirming and strengthening of some primary object of our regards. As our knowledge extends, we contract numerous associations with things purely ideal, as with historic places, persons, and incidents. I need only allude to the large field of ceremonies, rites, and formalities, which are cherished as enlarging the surface of emotional growths. The fine-art problem of distinguishing between original and derived effects consists in more precisely estimating these acquired pleasures.

The educationist could not but cast a longing eye over the wide region here opened up, as a grand opportunity for his art. It is the realm of vague possibility, peculiarly suited to sanguine estimates. An education in happiness pure and simple, by well-placed joyous associations, is a dazzling prospect. One of Sydney Smith's pithy sayings was, "If you make children happy now, you make them happy twenty years hence, by the memory of it." This referred, no doubt, to the home-life. It may, however, be carried out also in the school-life; and enthusiasm has gone the length of supposing that the school may be so well constituted as to efface the stamp of an unhappy home.

The growth of such happy associations is not the work of days; it demands years. I have endeavored to set forth the psychology of the case ("The Emotions and the Will," third edition, p. 89), and do not here repeat the principles and conditions that seem to be involved. But the thread of the present exposition would be snapped, if I were not to ask attention to the difference in the rate of growth when the

feelings are painful; the progress here is not so tedious nor so liable to thwarting and interruption.

With understood exceptions, pleasure is related physically with vitality, health, vigor, harmonious adjustment of all the parts of the system; it needs sufficiency of nutriment or support, excitement within due limits, the absence of everything that could mar or irritate any organ. Pain comes of the deficiency in any of these conditions, and is therefore as easy to bring about and maintain as the other is difficult. To evoke an echo or recollection of pleasure, is to secure, or at least to simulate, the copiousness, the due adjustment and harmony of the powers. This may be easy enough when such is the actual state at the time, but that is no test. What we need is to induce a pleasurable tone, when the actuality is no more than indifferent or neutral, and even, in the midst of actual pain, to restore pleasure by force of mental adhesiveness. A growth of this description is, on *a priori* grounds, not likely to be very soon reached.

On the other hand, pain is easy in the actual, and easy in the ideal. It is easy to burn one's fingers, and easy to associate pain with a flame, a cinder, a hot iron. Going as spectators to visit a fine mansion, we feel in some degree elated by the associations of enjoyment; but we are apt to be in a still greater degree depressed by entering the abodes of wretchedness, or visiting the gloomy chambers of a prison.

II. The facility of painful growths is not fully comprehended, until we advert to the case of passionate outbursts or the modes of feeling whose characteristic is explosiveness. These costly discharges of vital energy are easy to induce at first hand, and easy to attach to indifferent things, so as to be induced at second hand likewise. Very rarely are they desirable in themselves; our study is to check and control them in their original operation, and to hinder the rise of new occasions for their display. One of the best examples is terror, an explosive and wasteful manifestation of energy under certain forms of pain. If it is frequently stimulated by its proper causes, it attaches itself to by-standing circumstances with fatal readiness, and proceeds with no tardy steps. Next is irascibility, also an explosive emotion. It too, if ready to burst out by its primary causes, soon enlarges its borders by new associations. It is in every way more dangerous than terror. The state of fear is so miserable that we would restrain it if we could; the state of anger, although containing painful elements, is in its nature a luxurious mood; and we may not wish either to check it in the first instance, or to prevent it from spreading over collateral things. When any one has stirred our irascibility to its depths, the feeling overflows upon all that relates to him. If this be pleasure, it is a pleasure of rapid growth; even in tender years we may be advanced in hatreds. That combination of terror and irascibility giving rise to what is named antipathy is (unless strongly resisted) a state easy to assume and easy to cultivate, and is in wide

contrast with the slow growth of the pleasures typified under the foregoing head. A signal illustration of explosiveness is furnished by laughter, which has both its original causes, and also its factitious or borrowed stimulants. This is an instance where the severity of the agitation provokes self-control, and where advancing years contract rather than enlarge the sphere. As the expression of disparaging and scornful emotions, its cultivation has the facility of the generic passion of malevolence. We may refer, next, to the explosive emotion of grief, which is in itself seductive, and, if uncontrolled, adds to its primary urgency the force of a habit all too readily acquired. There is, moreover, in connection with the tender emotion, an explosive mode of genuine affection, of which the only defect is its being too strong to last: it prompts to a degree of momentary ardor that is compatible with a relapse into coldness and neglect. This, too, will spontaneously extend itself, and will exemplify the growth of emotional association with undesirable rapidity.

What has now been said is but a summary and representation of familiar emotional facts. Familiar also is the remark that explosiveness is the weakness of early life, and is surmounted to a great degree by the lapse of time and the strengthening of the energies. The encounter with others in every-day life begets restraint and control; and one's own prudential reflections stimulate a further repression of the original outbursts, by which also their growth into habits is retarded. In so far as they are repressed by influence from without, and counter-habits established, as a part of moral education, I have elsewhere stated what I consider the two main conditions of such a result—a powerful initiative, and an unbroken series of conquests. When these conditions are exemplified through all the emotions in detail, the specialties of the different genera—fear, anger, love, and the rest—are sufficiently obvious.

III. The chief interest always centres in those associations that, from their bearing on right and wrong conduct, receive the name "Moral." The class just described have this bearing in a very direct form; while the first class indirectly subserves moral ends. But when we approach the subject with an express view to moral culture, we must cross the field of emotional association in general by a new track.

The newly-appointed professors of the theory of education are perhaps not yet fully aware that, when they venture upon the troubled arena of moral education, they will not be able to evade the long-standing question, What is the moral faculty? A very short argument will prove the point. Moral improvement is obviously a strengthening of this so-called moral faculty, or conscience—increasing its might (in Butler's phrase) to the level of its right. But in order to strengthen an energy we must know what it is: if it is a simple, we must define it in its simplicity; if it is a compound, we must

assign its elements, with a view to define them. The unconventional handling of moral culture by Bentham and James Mill is strongly illustrative of this part of the case. Mill's view of the moral sense is the theory of thorough-going derivation; and, in delineating the process of moral education, he naturally follows out that view. He takes the cardinal virtues piecemeal; for example: "Temperance bears a reference to pain and pleasure. The object is, to connect with each pain and pleasure those trains of ideas which, according to the order established among events, tend most effectually to increase the sum of pleasures upon the whole, and diminish that of pains." The advocates of a moral faculty would have a different way of inculcating temperance—which, however, I will not undertake to reproduce.

It will not be denied, as a matter of fact, that the perennial mode of insuring the moral conduct of mankind has been punishment and reward—pain and pleasure. This method has been found, generally speaking, to answer the purpose; it has reached the springs of action of human beings of every hue. No special endowment has been needed to make man dread the pains of the civil authority. Constituted as we are to flee all sorts of pain, we are necessarily urged to avoid pain when it comes as punishment. Education is not essential to this effect any more than it is essential to our avoiding the pains of hunger, cold, or fatigue.

Those who demur to the existence of a special faculty, different from all the other recognized constituents of mind—feeling, will, or intellect—are not to be held as declaring that conscience is entirely a matter of education; for, without any education at all, man may be, to all intents and purposes, moral. What is meant by the derivative theory of conscience is, that everything that it includes is traceable to some one or other of the leading factors of our nature: first of all to will or volition, motived by pain and pleasure, and next to the social and sympathetic impulses. The coöperation of these factors supplies a nearly all-powerful impetus to right conduct, wherever there is the external machinery of law and authority. Education, as a third factor, plays a part, no doubt, but we may overrate as well as underrate its influence. I should not be far out in saying that seventy-five per cent. of the average moral faculty is the rough and ready response of the will to the constituted penalties and rewards of society.

At the risk of embroiling the theory of education in a controversy that would seem to be alien to it, I conceive it to be necessary to make these broad statements, as a prelude to inquiring what are the emotional and volitional associations that constitute the made-up or acquired portion of our moral nature. That education is a considerable factor is shown by the difference between the children that are neglected and such as are carefully tended; a difference, however, that means a good deal more than education.

When the terrors of the law are once thoroughly understood, it

does not seem as if any education could add to the mind's own original repugnance to incur them; and, on the other hand, when something in the nature of reward is held forth to encourage certain kinds of conduct, we do not need special instruction to prompt us to secure it. There is, indeed, one obvious weakness that often nullifies the operation of these motives, namely, the giving way to some present and pressing solicitation, a weakness that education might do something for, but rarely does. The instructor that could reform a victim to this frailty would effect something much wider than moral improvement properly includes.

Going in search of some distinct lines of emotional association that enhance the original impulses coincident with moral duty, I think I may cite the growth of an immediate, independent, and disinterested repugnance to what is uniformly denounced and punished as being wrong. This is a state or disposition of mind forming part of a well-developed conscience; it may grow up spontaneously under the experience of social authority, and it may be aided by inculcation; it may, however, also fail to show itself. This is the parallel of the much-quoted love of money for itself; but is not so facile in its growth. For one thing, the mind must not treat authority as an enemy to be counted with, and to be obeyed only when we can't do better. There must be a cordial acquiescence in the social system as working by penalties; and this needs the concurrence of good impulses together with reflection on the evils that mankind are saved from. It is by being favorably situated in the world, as well as by being sympathetically disposed, that we contract this repugnance to immoral acts in themselves, and without reference to the penalties that are behind; and thus perform our duties when out of sight, and not in the narrowness of the letter, but in the fullness of the spirit. It would take a good deal of consideration to show how the schoolmaster might coöperate in furthering this special growth.

THE NORWEGIAN LEMMING AND ITS MIGRATIONS.

By W. DUPPA CROTCH, M. A., F. L. S.

AMONG the many marvelous stories which are told of the Norwegian lemming (*Myodes lemmus*, Linn.), there is one which seems so directly to point to a lost page in the history of the world, that it is worth a consideration which it appears hitherto to have escaped. I allude to the remarkable fact that every member of the vast swarms which periodically almost devastate Norway perishes voluntarily, or at least instinctively, in the ocean. But as among my readers some may not be familiar with the lemming, a brief descrip-

tion of the animal itself will not be out of place. It is a vole, like our short-tailed field-mouse, very variable in size and color, but the figures (Fig. 1), which are about half the natural size, will be found to resemble the majority in the latter respect. The claws, especially on the fore-foot, are strong and curved; the tail is very short, the ears scarcely visible, and the bead-like, black eyes seem always to notice objects above them rather than those in any other direction. During the summer these animals form their nests under stones, usually betraying their habitations by the very care which they take to keep them

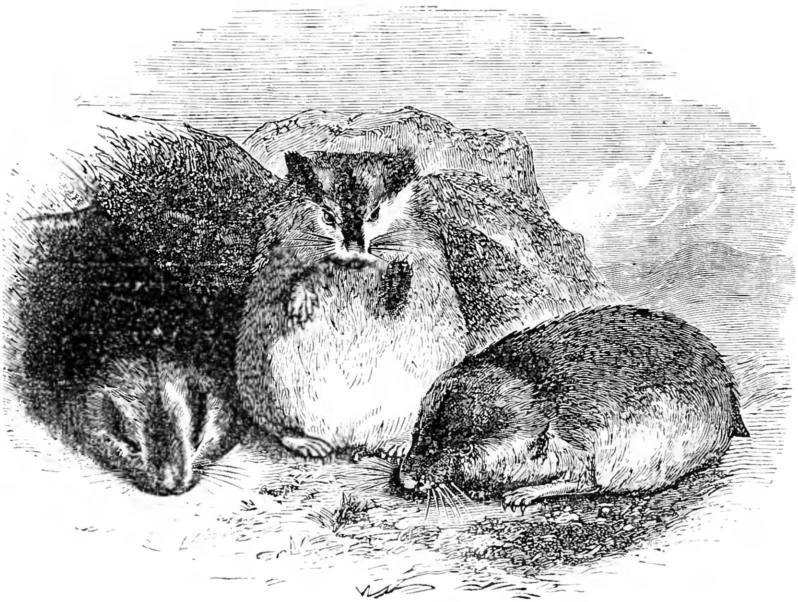


Fig. 1.—Group of Lemmings.

sweet and clean. In winter, however, they form long galleries through the turf and under the snow in search of their food, which is exclusively vegetable; and it is at this time that those ravages are caused which have led the Norwegians in former times to institute a special form of prayer against their invasions. There are several species of lemming, easily recognizable, and with well-marked geographical range; but it is to the Scandinavian species only that the following old description applies: "It lives on the shoots of the dwarf-birch, reindeer lichens, and other mosses; it hisses and bites; in winter it runs under the snow; and about every tenth year, especially before an extremely severe winter, the whole army of animals, in the autumn and at night, migrates in a direct line." According to Olaus Magnus they fall from the clouds; and Pennant narrates that "they descend from the Kjölen, marching in parallel lines three feet apart; they trav-

erse Nordland and Finmark, cross lakes and rivers, and gnaw through hay and corn stacks rather than go round. They infect the ground, and the cattle perish which taste of the grass they have touched; nothing stops them—neither fire, torrents, lakes, nor morasses. The greatest rock gives them but a slight check; they go round it, and then resume their march directly without the least division. If they meet a peasant they persist in their course, and jump as high as his knees in defense of their progress. They are so fierce as to lay hold of a stick and suffer themselves to be swung about before they quit their hold. If struck they turn about and bite, and will make a noise like a dog. Foxes, lynxes, and ermines, follow them in great numbers, and at length they perish, either through want of food or by destroying one another, or in some great water, or in the sea. They are the dread of the country, and in former times spiritual weapons were exerted against them; the priest exorcised them, and had a long form of prayer to arrest the evil. Happily it does not occur frequently—once or twice only in twenty years. It seems like a vast colony of emigrants from a nation overstocked, a discharge of animals from the northern hive which once poured forth its myriads of human beings upon Southern Europe. They do not form any magazine for winter provision, by which improvidence, it seems, they are compelled to make their summer migration in certain years, urged by hunger. They are not poisonous, as vulgarly reported, for they are often eaten by the Laplanders, who compare their flesh to that of squirrels."

M. Guyon disposes of the theory that these migrations are influenced by *approaching* severe weather, since the one witnessed by himself took place in the spring; also the superabundance of food during the previous autumn precluded all idea of starvation. He therefore adopts a third view, that excessive multiplication in certain years necessitates emigration, and that this follows a descending course, like the mountain-streams, till at length the ocean is reached. Mr. R. Collett, a Norwegian naturalist, writes that in November, 1868, a ship sailed for fifteen hours through a swarm of lemmings, which extended as far over the Trondhjems-fjord as the eye could reach.

I will now relate my own experience of the lemming during three migrations in Norway, and in a state of captivity in England. The situation of Heimdalen, where I reside during the summer months, is peculiarly well suited for observation of their migrations, lying as it does at an elevation of 3,000 feet, and immediately under the highest mountains in Scandinavia; and yet, excepting during migration, I have never seen or been able to procure a specimen. It was in the autumn of 1867 that I first heard the peculiar cry of the lemming, guided by which I soon found the pretty animal backed up by a stone, against which it incessantly jerked its body in passionate leaps of rage, all the while uttering a shrill note of defiance. The black, bead-

like eyes seemed starting from their sockets, and the teeth shone white in the sunlight. I hastily snatched at the savage little creature, but it sprang completely round, fastened its teeth sharply in my hand, and taking advantage of my surprise escaped under a large stone, whence I could not dislodge it. A Norwegian friend who accompanied me by no means shared my feelings of satisfaction at the sight of a lemming. "We shall have a severe winter and no grass next spring, owing to those children of Satan!" was his comment on the event. However, it was many a month before I saw another; then, on lifting a flat stone, I found six in a nest of dried grass, blind, and apparently but just born. In a few days the whole fjeld became swarming with these pretty voles; at the same time white and blue foxes made their appearance, and snowy owls and many species of hawks became abundant. My dogs, too, were annoyed by the rash courage of the new-comers, which would jump at their noses even when slowly drawing on game, so that they never spared a lemming, though they never ate them till last year, when I observed that they would eat their heads only, rejecting the body, although they devoured the common field-mouse to the end of his tail. As the season advanced and snow covered the ground, the footprints and headless carcasses told plainly how hard it must be for a lemming to preserve its life, although there can be no doubt that its inherent pugnacity is its worst enemy. In this country we fail to conceive how much active life goes on beneath the snow, which in more northern latitudes forms a warm roof to numerous birds, quadrupeds, and insects, which are thus enabled to secure an otherwise impossible sustenance. At the same time, as I have already noticed, a fearful struggle for existence is carried on during the long autumnal nights, before the snow has become a protection rather than a new source of danger to all save predaceous animals. It was a curious sight, when the whole visible landscape was an unbroken whiteness, to see a dark form suddenly spring from the surface and scurry over the snow, and again vanish. I found that some of the holes by means of which this feat was executed were at least five feet in depth, yet even here was no safety, for the reindeer often kill the lemmings by stamping on them, though I do not believe their bodies are ever eaten.

During the autumn I noticed no migration, or rather there was only an immigration from some point to the eastward, and in the subsequent migrations of 1870–'71, and 1875–'76, I still found the same state of things. The animals arrived during early autumn, and immediately began to breed; there was no procession, no serried bands undeterred by obstacles, but there was an invasion of temporary settlers, which were speedily shut out from human view by the snow, and it was not till the following summer that the army, reënforced by five or six generations, went out to perish like the hosts of Pharaoh. On calm mornings my lake, which is a mile

in width, was often thickly studded with swimming lemmings, every head pointing westward; but I observed that when my boat came near enough to frighten them they would lose all idea of direction, and frequently swim back to the bank they had left. When the least wind ruffled the water every swimmer was drowned; and never did frailer barks tempt a more treacherous sea, as the wind swept daily down the valley, and wrecked all who were then afloat. It is impossible not to feel pity for these self-haunted fugitives. A mere cloud passing over the sun affrighted them; the approach of horse, cow, dog, or man, alike roused their impotent anger, and their little bodies were convulsively pressed against the never-failing stone of vantage (*see* Fig. 1), while they uttered cries of rage. I collected 500 skins, with the idea of making a rug, but was surprised to find that a portion of the rump was nearly always denuded of hair, and it was long before I discovered that this was caused by the habit of nervously backing up against a stone, of which I have just spoken. As this action is excited by every appearance of an enemy, it seems surprising that a natural callosity should not take the place of so constant a lesion; possibly, however, the time during which this lesion occurs is too short to cause constitutional change.

Early in the autumn, and just a year after their arrival at Heimdalen, the western migration commenced anew. Every morning I found swarms of lemmings swimming the lake diagonally, instead of diverging from their course so as to go round it, and mounting the steep slopes of Heimdals-hö (Figs. 2 and 3) on their way to the coast,

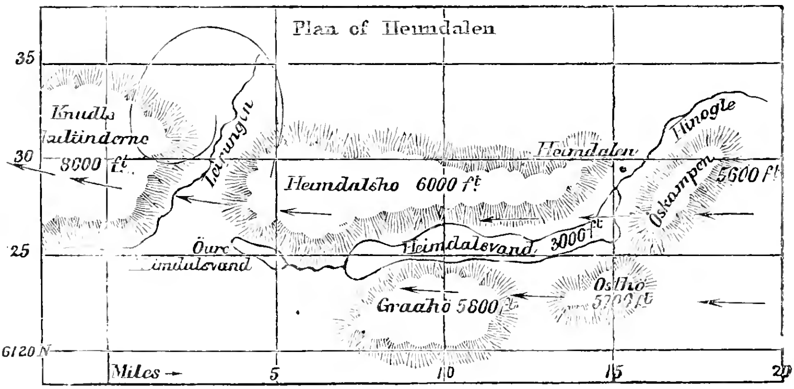


Fig. 2.—Plan of Heimdalen drawn to scale, in which the course of the Lemmings, indicated by the arrows, is seen to cross Lake Heimdalsvand and the swift river Leirungen, both of which might be avoided by a slight *détour*. The river is of glacier origin, very cold and very rapid.

where the harassed crowd, thinned by the unceasing attacks of the wolf, the fox, and the dog, and even the reindeer, pursued by eagle, hawk, and owl (*see* frontispiece), and never spared by man himself, yet still a vast multitude, plunges into the Atlantic Ocean on the first

calm day, and perishes with its front still pointing westward. No faint heart lingers on the way; and no survivor returns to the mountains.

There appears to have been a difficulty in keeping these restless creatures in captivity, both because they escape through incredibly small apertures (generally, however, dying from internal injuries thus caused), and because they will gnaw through a stout wooden cage in one night, and devote every spare moment to this one purpose, with a pertinacity worthy of Baron Trenck. At all events, few have been brought alive to this country, and none have survived. At present (February, 1877) I have one which I have preserved since September last, defeating his attempts at escape by lining the cage with tin, and allowing him a plentiful supply of fresh water, in which he is always dabbling. With the approach of winter all his attempts to escape ceased, and I now always take the little stranger for an airing in my closed hands while his bed is being made and his room cleaned out. He seems to like this, but after a few minutes a gentle nibble at my finger testifies to his impatience; and if this be not attended to, the

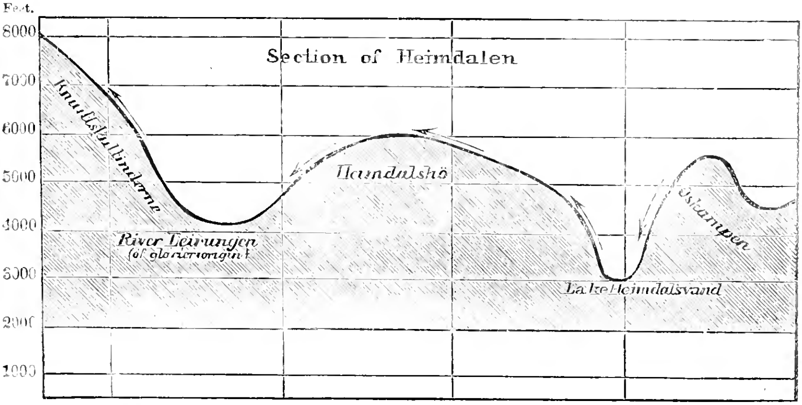


Fig. 3.—Section of Heimdalen showing the Lemmings' track, which does not follow the watershed.

biting progresses in a *crescendo* scale until it becomes unbearable, although it has never under these circumstances drawn blood. My little prisoner shows few other signs of tameness, but the fits of jumping, biting, and snarling rage have almost ceased. I expect, however, that, with the return of spring, the migratory impulse will be renewed, and that he will kill himself against the wires of his cage like a swallow.

The reader is now in a position to consider the three questions raised by the above facts, and those questions are as follow: 1. Whence do the lemmings come? 2. Whither do they go? 3. Why do they migrate at all? With regard to the first, no one has yet supplied an answer. They certainly do not exist in my neighborhood

during the intervals of migrations; and the Kjölen range was probably selected as their habitat, not because it was proved to be so, but because so little is known about it at all. The answer to the second question is certain: They go to the sea. Those on the east of the backbone of Norway go to the Gulf of Bothnia, and those on the west to the Atlantic Ocean (Fig. 4), and out of eighteen migrations which have been investigated, one only, and that very doubtful, is reported

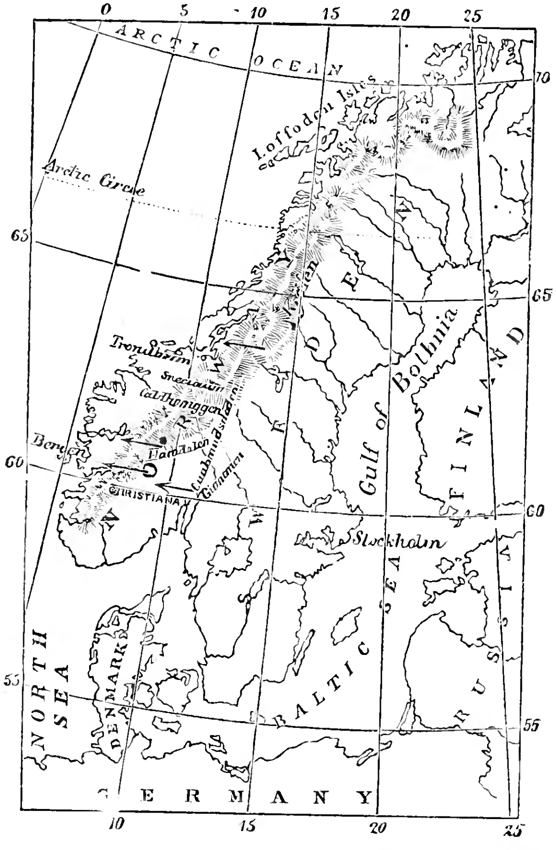


FIG. 4.—OUTLINE MAP OF SCANDINAVIA. The two main valleys, Gudbrandsdalen and the valley of the Glommen, run nearly north and south. The course of the Lemmings crosses these at right angles, as indicated by the arrows.

to have been directed southward. The question as to the cause of these migrations remains, and is a very difficult one to answer. We have been told that the foreknowledge of approaching severe weather predetermines the exodus: my experience, however, contradicts this, and it may be dismissed as merely a popular superstition. Unusual reproduction and consequent deficiency of food is a more plausible theory; but I have always noticed that, just as with the swallow, a

few individuals have preceded the main body, and that during the first autumn the numbers are never large, but, after a winter spent beneath the snow, they begin to breed with the first days of summer, and thus develop the extraordinary multitude which is, as it well may be, the astonishment and terror of the country. It appears, then, that excessive reproduction is rather the result than the cause of migration. It has also been suggested that the course taken by the lemmings follows the natural declivities of the country, but a reference to the maps will show that in that case nearly all the Norwegian migrations should take a southerly route, which is by no means the case. On the contrary, westward at Heimdalen means across a rapid river, over a wide lake, and up a steep, rocky, and snowy mountain, and this is the course which is followed. Now, this ends eventually in the ocean, and thus we are again landed at the question from which we set out. After all, it is not the power of direction which is so remarkable; this is a faculty possessed by many animals, and by man himself in a savage state. A young dog which I took from England, and then from my home in Vaage by a path to Heimdalen, a distance of forty-six miles, ran back the next morning by a direct route of his own, crossing three rapid rivers and much snow, and accomplishing the distance in six hours, without the vestige of a path. This same dog afterward repeated the feat, but followed the path, and took two days in reaching his destination, hindered and not aided, as I believe, by his experience. Herr Palmén, indeed, says, "Experience guides migration, and the older migrants guide the younger," like one of Mr. Cook's personally-conducted tours. This obviously cannot be the case with the lemmings.

It is now generally admitted that instinct is merely inherited experience, and is, therefore, primarily calculated to benefit the species, unless, indeed, circumstances have changed meanwhile more rapidly than the structures to which the phenomena of instinct are due. Now, the lemmings during their wanderings pass through a land of milk and honey, where, if their instincts could be appeased, they might well take up a permanent abode; and yet they pass on, while their congener, the field-vole, remains in quiet possession of the quarters from which he was temporarily ousted. It is, indeed, almost as strange a sight to see the holes, the deeply-grooved runs, and the heaps of refuse, of these restless creatures, which have passed away but yesterday, as it is to see the fjelds suddenly become alive with a new and boisterous tenant, who, like another Ishmael, has the hand of all men against him.

Now, if we compare the migration of the lemmings with that of our more familiar swallows, we find that the latter obviously seek a more genial climate and more abundant food, returning to us as surely as summer itself; nor do they ever, so far as I know, breed on their passage. The swifts, which stay but a short time with us, remain in

Norway barely long enough to rear their young before returning to Africa. It is difficult, in fact, to find a parallel case to that of the lemmings. The nearest approach, perhaps, is afforded by the strange immigration of Pallas's sand-grouse in 1863, when a species whose home is on the Tartar steppes journeyed on in considerable numbers to the most western shores of Europe, and very probably many perished, like the lemmings, in the waves of the Atlantic. But to revert to the swallows, which annually desert Europe to visit Africa. Let us suppose that these birds were partial migrants only—that is, that a remnant remained with us after the departure of the main body—and further suppose that the continent of Africa were to become submerged, would not many generations of swallows still follow their inherited migratory instincts, and seek the land of their ancestors through the new waste of waters, while the remaining stock, unimpeded by competition, would sooner or later, according to the seasons, recruit the ranks for a new exodus? It appears quite as probable that the impetus of migration toward this lost continent should be retained as that a dog should turn round before lying down on a rug, merely because his ancestors found it necessary thus to hollow out a couch in the long grass.

Well, then, is it probable that land could have existed where now the broad Atlantic rolls? All tradition says so; old Egyptian records speak of Atlantis, as Strabo and others have told us. The Sahara itself is the sand of an ancient sea, and the shells which are found upon its surface prove that no longer ago than the Miocene period a sea rolled over what now is desert. The voyage of the Challenger has proved the existence of three long ridges in the Atlantic Ocean, one extending for more than 3,000 miles; and lateral spurs may, by connecting these ridges, account for the marvelous similarity in the fauna of all the Atlantic islands. However, I do not suppose that the lemmings ever went so far south, though they are found as fossils in England; but it is a remarkable fact that, while the soundings off Norway are comparatively shallow for many miles, we find a narrow but deep channel near Iceland, which probably has prevented the lemming from becoming indigenous there, although an American species was found in Greenland during the late arctic expedition. If, as is probable, the Gulf Stream formerly followed this deep channel, its beneficent influence would only extend a few miles from the coast, which would also have reached to a great distance beyond the present shores of Norway, and thus the lemmings would have acquired the habit of traveling westward in search of better climate and more abundant food; and, as little by little the ocean encroached on the land, the same advantages would still be attained. And thus, too, we find an explanation of the fate which befalls the adventurous wanderers; for we have already seen that no lake deters them, and that they frequently cross the fjords, or arms of the sea, in safety. No

doubt, therefore, they commit themselves to the Atlantic in the belief that it is as passable as those lakes and fjords which they have already successfully dared, and that beyond its waves lies a land which they are never destined to reach.

The submerged continent of Lemuria, in what is now the Indian Ocean, is considered to afford an explanation of many difficulties in the distribution of organic life, and I think the existence of a Miocene Atlantis will be found to have a strong elucidative bearing on subjects of greater interest than the migration of the lemming. At all events, if it can be shown that land existed in former ages where the North Atlantic now rolls, not only is a motive found for these apparently suicidal migrations, but also a strong collateral proof that what we call instincts are but the blind and sometimes even prejudicial inheritance of previously-acquired experience.—*Popular Science Review.*

MATCHES.

By JOHN A. GARVER, A.B.

AN article in The Popular Science Monthly of last November gave an interesting account of the early history of fire, showing how that important element was obtained in primitive times. We will now consider the development of the modern art of extemporizing fire. In a match-making age those crude and ancient processes are regarded with curiosity, but that they ever possessed any practical value is scarcely realized; while the use of our prompt and cheap devices for producing combustion has grown to be such a matter of course that a thought is hardly given to the time when they did not exist. During the whole of the last century, however, and in the early part of the present century, the invention of a safe and trustworthy agent for furnishing fire was regarded as one of the great wants of the age; and fifty years ago a tinder-box was as much an indispensable article of household economy as is the well-filled match-safe to-day. The sulphur-match now in use is not so old as our railroads, and but a few years ago there occurred frequent examples of burns caused by the explosion of the match and the projection of its burning pieces.

Among the more civilized nations, the tinder-box, with the flint and steel, became known in the fourteenth century, and continued to be used, notwithstanding the other methods, down to the invention of the lucifer-match. The tinder was formed by the partial combustion of a linen or cotton rag, and, being ignited by striking a spark upon it from the flint and steel, communicated its fire in turn to the match.

When phosphorus was first discovered, two hundred years ago, it

was utilized in London by rubbing it between two pieces of brown paper. A fire was produced in this way, which lighted a splint tipped with sulphur. Another early method was to put a piece of phosphorus in a vial and stir it with a hot iron wire, after which the vial was corked tightly for use. As the phosphorus was partially burned in the confined portion of the air, the interior of the vial became covered with oxide of phosphorus. When a light was desired, a sulphur-tipped splint was dipped into the bottle, a portion of the phosphorus adhered to it, and, being brought into the air, the chemical action between the two substances caused a flame which lighted the splint.

When chlorate of potash is mixed with loaf-sugar, a drop of sulphuric acid let fall on the compound will produce a brilliant flame. This principle involved the next stage in the development of the match. The end of the splint was tipped with the mixture, colored with vermilion, and ignited in a little bottle containing asbestus and sulphuric acid. The various ingredients were then put into a handsome metal case, and the patent was ready to take its place among the wealthy; for, at first, a single case of a hundred sold for four dollars and seventy-five cents. There were certain drawbacks to the practical use of this invention, as the acid would become weak by absorbing moisture from the air, and the match, instead of producing the brilliant flame expected, merely smouldered and spurted the acid about, to the detriment of good clothes and a peaceful disposition. As a stroke of economy, such a wetted match was occasionally put back among the rest for future use; but, coming in contact with one more energetic, it ignited the latter, and thus the whole collection was lighted at once and shot out in all directions. From this dip-splint, oxymuriate match, or instantaneous light-box, as it was variously termed, lucifers trace their lineal descent.

John Walker, an Englishman, is generally supposed to have invented lucifer-matches in 1829. The first real friction-match was made in England in 1832, and was a compound of chlorate of potash and sulphuret of antimony. It was ignited by strong compression between two pieces of sand-paper, and, as a natural consequence, the heads frequently flew off in all directions. A year or two later, phosphorus was substituted for the antimony; the matches were called "congreves," and the composition continued to be improved by using other constituents for part of the chlorate of potash.

The ease with which phosphorus is ignited by friction has caused it to be employed universally in the manufacture of matches. The particular proportions and the exact ingredients which make up the head of the match are jealously guarded by the manufacturers, each one claiming some advantage over the others. From one-twelfth to one-tenth is laid down as the best proportion of phosphorus to be employed. Glue, gum, or similar substances, are used for causing the composition to adhere to the splint. The use of glue is objectionable, as it

carbonizes and prevents combustion. In preparing the compound, the mucilaginous substance is dissolved in water till it assumes the consistency of thin sirup. After it is heated, the phosphorus is added in small pieces, and thoroughly incorporated by rubbing till cold. If it were left in this condition, however, the mass, upon becoming cold, would prevent the admission of air and hinder combustion. Some additional substance is necessary to supply the oxygen to it, such as red-lead, saltpetre, or chlorate of potash. Coloring-matter is also usually put into the solution: vermilion, if the tips are to be red; Prussian blue, if they are to be blue, etc. In making sulphur-matches, the ends of the splints are first dipped into melted sulphur, and afterward touched to the surface of the phosphorus-paste. In lighting such a match, the process is as follows: the coating of the head is broken by friction, the phosphorus is kindled, and the heat of its combustion decomposes the salts; these, in their decomposition, evolve oxygen, which provides the fuel, increases the heat, and causes the ignition of the sulphur, which in turn inflames the wood. The temperature required for kindling matches varies from 150° to 160° Fahr. The sulphur is what causes the peculiar brimstone-odor. Instead of sulphur, stearin, stearic acid, or paraffin, is used in the better kinds of matches. They burn more readily than the sulphur-matches, as the fatty matter and wood take fire together, while in the others the sulphur must first be consumed before the wood is ignited. The matches soaked in fatty matter also burn with a clearer and brighter light, and are free from the disagreeable odor due to the sulphur. A coating of varnish is sometimes employed to protect the head from moisture.

Before a box of matches can be sold, it has passed through about forty different processes, twenty for the matches and as many for the box. The wood used for the splints is commonly white-pine, free from knots. Other woods are also occasionally employed, as beech, birch, willow, poplar, and cedar. Much of the wood for this purpose is brought from Canada, and the match-manufacture is assuming such large proportions that it is making serious inroads into the supply of clear white-pine timber needed for other purposes. Formerly, the splints were cut by hand, and the composition was applied by the same means. Separate factories are now commonly employed for making the splints, and the entire labor is performed by machinery. As the manufacturers do not allow visitors in their buildings, it is impossible to describe exactly the machinery or the methods employed. By one process, the pine-wood is reduced to two-inch planks, which are cut into blocks the length of the ordinary match. These are put into a small machine, which at each stroke cuts off twelve splints, and at the following stroke delivers them upon an endless chain, which carries them to a sulphur-bath, where a wheel, revolving in the sulphur, coats their ends as they pass; farther on, a similar wheel applies the phosphorus. In this condition the matches are brought back across

the room, delivered in trays near the cutting-machine, and thence sent to the packing-room. In wax-matches, or vestas, the composition is attached to a few cotton-threads immersed in a mixture of paraffin and stearin. One or two hundred of these wicks are rolled around a cylinder and separated by a comb. They pass through a bath of melted wax and are afterward drawn through holes in a metal frame, which renders the tapers smooth, cylindrical, and of the proper size and shape. A mechanical knife cuts, at one time, all the wicks according to the determined length, from one to one and a quarter inch, after which the paste is applied to their ends with great rapidity.

In the manufacture of matches much trouble has been occasioned by the use of phosphorus, as its fumes attack the teeth of the workmen, and give rise to a disease known as caries of the jaw-bones. In some of the small and poorly-managed factories the men and children are never free from the fumes; their clothes and breath are luminous in the dark, and in the daytime white fumes may be seen escaping from them whenever they are seated by the fire. The phosphorus first attacks a decayed tooth, causing pain which constantly becomes greater. The gums are sore, the face swollen, and the teeth finally drop out. The suffering is excruciating, the patient finds little relief for months or years, and, in a severe case, there is loss of one or both jaw-bones, hindering mastication and ending in death. So alarming did this disease become in Germany at one time that it attracted the attention of the Government. No antidote has yet been discovered; but it can be prevented to a great extent by ventilation and cleanliness. We have inquired of several of the leading American manufacturers in regard to the subject, and all say that their workmen are not troubled in this manner. No examination of their teeth is enforced, the men being merely warned as to the consequences before they begin their work.

Partly as a remedy for this evil, the red or amorphous phosphorus was substituted for the ordinary variety. This possesses neither odor nor taste, is not poisonous, and can be handled with safety. The danger arising from the use of matches was magnified, bacause they could sometimes be seen in the dark, were liable to ignite on a warm shelf, and were poisonous to such an extent that children had been killed by using them as playthings. From red phosphorus resulted the safety-match. Many attempts were made to form a paste with red phosphorus and chlorate of potash without success, and finally the paste and phosphorus were separated. The heads now consist of a pasty mass composed mainly of sulphuret of antimony and chlorate of potash. The red phosphorus, mixed with very fine sand or other substance, is glued to the box in which the matches are contained. It is impossible to light such matches by friction upon any common rough surface, though they at once burst into flame when rubbed upon the phosphorus composition on the box. They can sometimes be lighted

without application to the phosphorus on the box, by drawing them several times with long sweeps over such surfaces as glass, ebony, etc. When they were first introduced into England the use of any other kind in the public buildings was forbidden by a special act of Parliament. Their manufacture has been encouraged in several European countries, and in times past their use has by some governments been enjoined by law. These matches are also called "hygienic," because they can be put into the mouth without danger.

Another kind of safety-match, which has never come into general use, contained the phosphorus at one end and the chlorate of potash at the other. The match is lighted by breaking it in halves and rubbing the two ends together.

In Switzerland, safety-matches are almost the only ones in the market, and in Sweden they are largely manufactured for exportation. A firm in New York imported the latter for many years, but the customs-duty was so high, and the demand so slight, that the business was abandoned. One of the former partners stated that, if the American people would show any desire for the matches, he could furnish them much cheaper than the matches produced in this country, as in Sweden the materials are provided at a very trifling expense. But, as he expressed it, "an American prefers to put his hand into his pocket, take out a match, and strike it on his pantaloons or shoe, to economizing by carrying them around in the box in which he buys them. And you could never get the Irish servants here to use safety-matches unless you had the priest on your side."

Factories for the production of safety-matches were established in New York, Boston, and other places, but they have all failed with the exception of one in Erie, Pennsylvania, which, with the assistance of some of the wax and parlor manufacturers, easily supplies the demand created in this country. Those made by Bryant & May, in England, are also found in the shops here. The great objection to safety-matches seems to be due to the fact that they are so difficult to carry about. In France they are regarded with great disfavor by the population. No one cares to be troubled with an angular box which he must hold in his hand till he has lighted his match; and it is impossible to put the phosphorus compound on a small pocket match-safe, as the surface is not sufficiently great, and the phosphorus soon rubs off.

A gentleman who has been employed in the manufacture of safety-matches expressed it as his opinion that they are the most dangerous matches made. For in the majority of cases, when a match is struck, some of the phosphorus on the box flies off, and, being highly inflammable, if it meets with any combustible substance, it always gives rise to a danger of fire. If lighted where the phosphorus can fall upon the carpet, the result is the same as though the carpet were exposed to the sparks of a fire. There is also a certain degree of temptation offered to those who manufacture these matches. This consists

in putting a small quantity of phosphorus into the heads to make them ignite more easily when brought into contact with the phosphorus on the box. This fraud has actually been carried into effect in Northern Germany, and, although nothing of the kind has been discovered in this country, the fact that it may be will probably increase their unpopularity. The safety-match has certainly had time to win its way, as an old variety of it existed in Switzerland at a period when other parts of the world were still occupied with the flint and steel. It has been claimed for these matches that they are better able to resist moisture than other varieties. The reason, however, is not apparent, as the heads are composed of salts, which are affected by water in the manner of all saline substances. It may be stated as a general rule that those matches are safest which require considerable friction for ignition, and which, when lighted, furnish merely heat enough to kindle the splints. The safest, probably, are those in which a considerable part of the compound is formed of sulphur, as it requires more than usual friction to light them. They are also a quiet match, and in lighting do not scatter any part of the head about. But they kindle slowly, and the sulphurous fumes always render them objectionable. They can also be lighted so conveniently by rubbing them on the wall that a great temptation is held out to servants to disfigure the appearance of a room in this way.

About twenty years ago parlor-matches began to be manufactured and have ever since been growing in favor. No sulphur is used in them, and in their freedom from odor, their convenience and rapidity in lighting, they have a decided advantage over all others. Their noisy explosion is occasioned by chlorate of potash, and may be prevented by substituting nitrate of potash. They are said to be superior to the German match, owing, perhaps, to the fact that they are not coated with varnish. They seem to have attained their greatest popularity in the Western and Southern States, and are used pretty generally among the wealthier classes. Swift & Courtney, who have factories in four different cities, manufacture about 1,500 gross of these daily, and state that the demand for them is constantly increasing. They are nearly half again as expensive as the sulphur-match, and grocers and retail jobbers are inclined to increase their price. There is, however, but a small difference between the cost of matches with sulphur and those in which stearic acid is used, as much more sulphur is required than stearic acid. They partake of the same danger that attends the employment of the safety-match, for if they are tipped too profusely the burning material will scatter to some distance. They take fire easily if any one happens to step upon them, and require to be guarded carefully where there are children. But the danger from their use is not alarming, and insurance companies make but little distinction in their rates between these and others. It is a mistaken idea that the invention of matches has caused much dif-

ference in the number of fires; and, if a certain kind of match is preferred for its convenience, it will not be abandoned because it has an extra element of danger. Fires may result from the overturning of a box by a cat or dog, or by the gnawing of the ends of matches by rats or mice; but these occurrences are exceptional, and rarely happen.

There is said to be only one factory in America where wax-matches are now produced. This has been established within the last few years, is running altogether with French machinery, and is supplying a growing demand. The makers of wax-matches do not come into competition with other manufacturers, but find their custom among those who are attracted especially by the novelty and pleasing appearance of the matches. Their higher cost prevents them from coming into general use, and the fact that there is a monopoly in their manufacture exerts some influence in regard to the price. Great care is taken in the designs for the boxes, and no pains are spared to make them ornamental and attractive. Improvements and new patents are constantly being made in them. The most recent variety has a small hole in the lid which acts as a candlestick. As soon as the match is lighted, the unburned end is inserted in the lid of the box, and an illumination is provided which lasts according to the length of the taper. The usual wax-match gives a fine light, which continues one or two minutes—that is, four or five times as long as wooden matches. This can be increased with their length, and a very respectable impromptu candle may be obtained by the contrivance referred to. Further attractions are provided by arranging the differently-colored heads according to curious and artistic devices. They can be purchased, having a composition resembling the parlor-match, or in the form of safety-matches. All wax-matches must be made so that they will take fire upon slight friction on account of the less resistance afforded by the body of the match; but they are not on this account any more dangerous than the parlor-match. Though sometimes used by smokers, they are not well suited to this purpose, as in lighting a cigar the fatty matter can be detected by the taste.

The Japanese have contributed their stock of curiosities to this department also. They have a variety of paper matches, which burn with a small, scarcely luminous flame, forming, as the combustion advances, a red-hot ball of glowing saline matter. When the match has been partly consumed, a succession of bright sparks shoots out from the head, and gradually a brilliant scintillation is formed similar to that observed in burning a steel spring in oxygen, only much more delicate, the separate sparks branching out in beautiful forms. These matches are composed of carbon, nitre, and sulphur, and there has been no difficulty in imitating them.

Many efforts have been made to construct the heads of matches without phosphorus. There is a match in Germany at the present time in which this result has been reached, but none of the cases dis-

covered seem to be perfectly satisfactory. Dr. Jettel has made a careful examination of the subject, and has arrived at the conclusion that the ingredients prepared to take the place of phosphorus render the match more difficult to ignite, while they are not perfectly harmless, but merely less dangerous. They are more sensitive to moisture; it is more difficult for the maker to secure a satisfactory result; and hence more expensive for the buyer. The Germans in nearly all their matches use a much smaller proportion of phosphorus than is done elsewhere, but the material must yet be found which will take its place entirely.

Accidents may be occasioned by throwing half-burned matches carelessly aside, and allowing them to smoulder near combustible substances. Various chemical solutions have been compounded in which the match is to be soaked, so that, as soon as it is blown out, the fiery mass of carbon will become black. Solutions of this kind are alum, borax, Glauber salts, or Epsom salts. Matches thus prepared are, of course, rendered more expensive.

While so much has been accomplished in the way of getting a quick fire without exertion, there is still room for considerable improvement. A safety-match has yet to be invented which will contain the entire composition on its own head. A water-proof match is desired, but has never been invented. There are firms which represent that they make water-proof matches, and the scientific journals contain from time to time receipts to effect this purpose. But they are not proof to water in the sense in which that is generally understood. Most matches may be put into the mouth or dipped into water for an instant, but none of them will bear a drenching or continued exposure to a moist atmosphere. The safety-match is objectionable for several reasons, the parlor-match from its tendency to scatter about bits of the head, and the sulphur-match from its brimstone-odor.

Matches have been made in which camphor and frankincense were mixed with the paste, and the wood of the match was of cedar, so that an agreeable odor was diffused in getting a light. So the time may come when the fashionable match, in addition to its other excellent qualities, will have such a delicate fragrance that it will be a pleasure merely to light it.

In 1864 the Government required a one-cent stamp to be placed on every package of matches. In anticipation of the tax a large quantity had been manufactured, so that for the first two years the legitimate revenue was not derived. In 1865 the receipts obtained in this manner amounted to about $1,000,000, but since then they have greatly increased, so that the stamp-tax now forms a large part of the cost. In comparison with other branches of business this product of industry probably affords the largest revenue accruing under the excise. Owing to this tax several large firms either failed or retired; and at the present time the manufacturer of sulphur-matches, by the

greatest care and economy, secures but a small margin on his sales. A heavy tax of this kind is liable to defeat its own object, as is exemplified by numerous facts. Thus, in 1865, matches were imported into the United States from New Brunswick, and sold in packages suitable for the retail trade without paying any tax under the internal-revenue law. When, a few years ago in England, a stamp-duty was put upon matches, the opposition was so violent that the attempt had to be abandoned.

In 1872 the French Government, desiring an additional source of revenue, determined to extract it from their matches. They therefore let to a single great company the sole right of making them for twenty years, and agreed to buy up all the old factories and furnish the company with new ones. In return the latter was to pay a fixed rent of $3,200,000 per annum. It was furthermore stipulated that the price of the matches should not be raised, but the company is already accused of treating this as a dead letter. The matches are said to be so bad that they will hardly light, and the peasants, instead of buying them, use a match of home-manufacture, made by steeping hemp in sulphur. Great trouble and expense have been incurred by the state; the company has been despotic and unable to fulfill its obligations; a proposition has been made and rejected on the part of the Government to reduce the rent one-half; and the probabilities are, that the lease will expire before the time agreed upon.

The extent to which the manufacture of matches is carried can be but faintly indicated by means of figures. The demand for them in Great Britain is, on an average, eight daily for each individual; in Belgium, nine per head; and, for Europe and North America, the entire average is six for every inhabitant. To meet this demand matches are produced by the million, and the waxed taper, before division into small pieces, is measured by the mile. It is stated that one pound of phosphorus is sufficient for 1,000,000 matches, though the proportion varies greatly. In France there are consumed for this purpose 70,000 pounds of phosphorus every year. The largest makers are in Austria, two of whom use twenty tons of phosphorus per annum, and produce nearly 45,000,000,000 matches. One firm in New York uses annually 700,000 feet of choice white-pine timber, 100,000 pounds of sulphur, and 150 tons of straw-board for their boxes. Large quantities are exported from the United States to the East and West Indies, China, South America, and other countries. At the census taken here in 1870 there were found to be 75 establishments engaged in the business, and the value of the products for that year was $3,540,000.

THE IMPORT OF PROTOPLASM.[1]

By MICHAEL FOSTER, M. D., F. R. S.

AMONG the simpler organisms known to biologists, perhaps the most simple as well as the most common is that which has received the name of Amœba. There are many varieties of amœba, and probably many of the forms which have been described are, in reality, merely amœbiform phases in the lives of certain animals or plants; but they all possess the same general characters. Closely resembling the white corpuscles of vertebrate blood, they are wholly or almost wholly composed of undifferentiated protoplasm, in the midst of which lies a nucleus, though this is sometimes absent. In many a distinction may be observed between a more solid external layer, or *ectosarc*, and a more fluid granular interior, or *endosarc*; but in others even this primary differentiation is wanting. By means of a continually occurring flux of its protoplasmic substance, the amœba is enabled from moment to moment not only to change its form, but also to shift its position. By flowing round the substances which it meets, it, in a way, swallows them; and, having digested and absorbed such parts as are suitable for food, ejects or rather flows away from the useless remnants. It thus lives, moves, eats, grows, and after a time dies, having been during its whole life hardly anything more than a minute lump of protoplasm. Hence to the physiologist it is of the greatest interest, since in its life the problems of physiology are reduced to their simplest forms.

Now, the study of an amœba, with the help of knowledge gained by the examination of more complex bodies, enables us to state that the undifferentiated protoplasm, of which its body is so largely composed possesses certain fundamental vital properties:

1. It is contractile.—There can be little doubt that the changes in the protoplasm of an amœba, which bring about its peculiar "amœboid" movements, are identical in their fundamental nature with those which, occurring in a muscle, cause a contraction; a muscular contraction is essentially a regular, an amœboid movement an irregular flow of protoplasm. The body of the amœba may therefore be said to be contractile.

2. It is irritable and automatic.—When any disturbance, such as contact with a foreign body, is brought to bear on the amœba at rest, movements result. These are not passive movements, the effects of the push or pull of the disturbing body, and therefore proportionate to the force employed to cause them, but active manifestations of the contractility of the protoplasm; that is to say, the disturbing cause or

[1] From the introduction to M. Foster's "Text-Book of Physiology."

stimulus sets free a certain amount of energy previously latent in the protoplasm, and the energy set free takes on the form of movement. Any living matter which, when acted on by a stimulus, thus suffers an explosion of energy, is said to be "irritable." The irritability may, as in the amœba, lead to movement; but in some cases no movement follows the application of the stimulus to irritable matter, the energy set free by the explosion taking on some other form (heat, etc.) than movement. Thus a substance may be irritable and yet not contractile, though contractility is the most common manifestation of irritability.

The amœba (except in its prolonged quiescent stage) is rarely at rest. It is almost continually in motion. The movements cannot always be referred to changes in surrounding circumstances acting as stimuli; in many cases the energy is set free in consequence of internal changes, and the movements which result are called spontaneous or automatic[1] movements. We may, therefore, speak of the protoplasm of the amœba as being irritable and automatic.

3. It is receptive and assimilative.—Certain substances serving as food are received into the body of the amœba, and, being there in large measure dissolved, become part and parcel of the body of the amœba—become, in fact, fresh protoplasm.

4. It is metabolic and secretory.—*Pari passu* with the reception of new material, there is going on an ejection of old material, for the increase of the amœba by the addition of food is not indefinite. In other words, the protoplasm is continually undergoing chemical change (metabolism), room being made for the new protoplasm by the breaking up of the old protoplasm into products which are cast out of the body and got rid of. These products of metabolic action have, in all probability, subsidiary uses. Some of them, for instance, we have reason to think, are of value in the solution and preliminary changes of the raw food mechanically introduced into the body of the amœba; and hence are retained within the protoplasm for some little time. Such products are generally spoken of as "secretions." Others, which pass more rapidly away, are generally called "excretions." The distinction between the two is an unimportant and frequently accidental one. The energy expended in the movements of the amœba is supplied by the chemical changes going on in the protoplasm by the breaking up of bodies possessing much latent energy into bodies possessing less. Thus the metabolic changes which the food undergoes in passing through the protoplasm of the amœba (as distinguished

[1] This word has recently acquired a meaning almost exactly opposite to that which it originally bore, and an automatic action is now by many understood to mean nothing more than an action produced by some machinery or other. In this work I use it in the older sense, as denoting an action of a body, the causes of which appear to lie in the body itself. It seems preferable to "spontaneous," inasmuch as it does not necessarily carry with it the idea of irregularity, and bears no reference to a "will."

from the undigested stuff mechanically lodged for a while in the body) are of three classes: those preparatory to and culminating in the conversion of the food into protoplasm; those concerned in the discharge of energy; and those tending to economize the immediate products of the second class of changes by rendering them more or less useful for the first.

5. It is respiratory.—Taken as a whole, the metabolic changes are preëminently processes of oxidation. One article of food—i. e., one substance taken into the body, viz., oxygen—stands apart from all the rest; and one product of metabolism peculiarly associated with oxidation—viz., carbonic acid—stands also somewhat apart from all the rest. Hence, the assumption of oxygen and the excretion of carbonic acid, together with such of the metabolic processes as are more especially oxidative, are frequently spoken of together as constituting the respiratory processes.

6. It is reproductive.—The individual amœba represents a unit. This unit, after a longer or shorter life, having increased in size by the addition of new protoplasm in excess of that which it is continually using up, may by fission (or by other means) resolve itself into two (or more) parts, each of which is capable of living as a fresh unit or individual.

Such are the fundamental vital qualities of the protoplasm of an amœba; all the facts of the life of an amœba are manifestations of these protoplasmic qualities in varied sequence and subordination. The higher animals, we learn from morphological studies, are in reality groups of amœbæ peculiarly associated together. All the physiological phenomena of the higher animals are similarly the results of these fundamental qualities of protoplasm peculiarly associated together. The dominant principle of this association is the physiological division of labor corresponding to the morphological differentiation of structure. Were a larger or "higher" animal to consist simply of a colony of undifferentiated amœbæ, one animal differing from another merely in the number of units making up the mass of its body, without any differences between the individual units, progress of function would be an impossibility. The accumulation of units would be a hindrance to welfare rather than a help. Hence, in the evolution of living beings through past times, it has come about that in the higher animals (and plants) certain groups of the constituent amœbiform units or cells have, in company with a change in structure, been set apart for the manifestation of certain only of the fundamental properties of protoplasm, to the exclusion or at least to the complete subordination of the other properties.

These groups of cells, thus distinguished from each other, at once by the differentiation of structure and by the more or less marked exclusiveness of structure, receive the name of "tissues." Thus, the units of one class are characterized by the exaltation of the contrac-

tility of their protoplasm, their automatism, metabolism, and reproduction, being kept in marked abeyance. These units constitute the so-called muscular tissue. Of another tissue—viz., the nervous—the marked features are irritability and automatism, with an almost complete absence of contractility and a great restriction of the other qualities. In a third group of units, the activity of the protoplasm is largely confined to the chemical changes of secretion, contractility and automatism (as manifested by movement) being either absent or existing to a very slight degree. Such a secreting tissue, consisting of epithelium-cells, forms the basis of the mucous membrane of the alimentary canal. In the kidney, the substances secreted by the cells, being of no further use, are at once ejected from the body. Hence the renal tissue may be spoken of as excretory. In the epithelium-cells of the lungs, the protoplasm plays an altogether subordinate part in the assumption of oxygen and the excretion of carbonic acid. Still, we may, perhaps, be permitted to speak of the pulmonary epithelium as a respiratory tissue.

In addition to these distinctly secretory or excretory tissues, there exist groups of cells specially reserved for the carrying on of chemical changes, the products of which are neither cast out of the body nor collected in cavities for digestive or other uses. The work of these cells seems to be of an intermediate character: they are engaged either in elaborating the material of food that it may be the more easily assimilated, or in preparing used-up material for final excretion. They receive their material from the blood, and return their products back to the blood. They may be called the metabolic tissues *par excellence*. Such are the fat-cells of adipose tissue, the hepatic cells (as far as the work of the liver other than the secretion of bile is concerned), and, in general, the blood.

Each of the various units retains, to a greater or less degree, the power of reproducing itself, and the tissues generally are capable of regeneration in kind. But neither units nor tissues can reproduce other parts of the organism than themselves, much less the entire organism. For the reproduction of the complex individual, certain units are set apart in the form of ovary and testis. In these, all the properties of protoplasm are distinctly subordinated to the work of growth.

Lastly, there are certain groups of units—certain tissues which are of use in the body of which they form a part, not by reason of their manifesting any of the fundamental qualities of protoplasm, but on account of the physical and mechanical properties of certain substances which their protoplasm has been able, by virtue of its metabolism, to manufacture and to deposit. Such tissues are bone, cartilage, connective tissue in large part, and the greater portion of the skin.

We may, therefore, consider the complex body of a higher animal

as a compound of so many tissues, each tissue corresponding to one of the fundamental qualities of protoplasm, to the development of which it is specially devoted by the division of labor. It must, however, be remembered, that there is a distinct limit to the division of labor. In each and every tissue, in addition to its leading quality, there are more or less pronounced remnants of all the other protoplasmic qualities. Thus, though we may call one tissue *par excellence* metabolic, all the tissues are, to a greater or less extent, metabolic. The energy of each, whatever be its particular mode, has its source in the breaking up of the protoplasm. Chemical changes, including the assumption of oxygen and the production, complete or partial, of carbonic acid, and therefore also entailing a certain amount of secretion and excretion, must take place in each and every tissue. And so with all the other fundamental properties of protoplasm; even contractility, which, for obvious mechanical reasons, is soonest reduced where not wanted, is present in many other tissues besides muscle. And it need hardly be said that each tissue retains the power of assimilation. However thoroughly the material of food be prepared by digestion and subsequent metabolic action, the last stages of its conversion into living protoplasm are effected directly and alone by the tissue of which it is about to form a part.

Bearing this qualification in mind, we may draw up a physiological classification of the body into the following fundamental tissues:

1. The eminently contractile: the muscles.
2. The eminently irritable and automatic: the nervous system.
3. The eminently secretory or excretory: digestive, urinary, and pulmonary, etc., epithelium.
4. The eminently metabolic: fat-cells, hepatic cells, lymphatic and ductless glands.
5. The reproductive: ovary, testis.
6. The indifferent or mechanical: cartilage, bone, etc.

All these separate tissues, with their individual characters, are, however, but parts of one body; and in order that they may be true members working harmoniously for the good of the whole, and not isolated masses, each serving its own ends only, they need to be bound together by coördinating bonds. Some means of communication must necessarily exist between them. In the mobile, homogeneous body of the amœba, no special means of communication are required. Simple diffusion is sufficient to make the material gained by one part common to the whole mass, and the native protoplasm is physiologically continuous, so that an explosion set up at any one point is immediately propagated throughout the whole irritable substance. In the higher animals the several tissues are separated by distances far too great for the slow process of diffusion to serve as a sufficient means of communication, and their primary physiological continuity is broken by their being imbedded in masses of formed material, the product of

the indifferent tissues, which, being devoid of irritability, present an effectual barrier to the propagation of molecular explosions. It thus becomes necessary that, in the increasing complexity of animal forms, the process of differentiation should be accompanied by a corresponding integration, that the isolated tissues should be made a whole by bonds uniting them together. These bonds, moreover, must be of two kinds.

In the first place, there must be a ready and rapid distribution and interchange of material. The contractile tissues must be abundantly supplied with material best adapted by previous elaboration for direct assimilation, and the waste products arising from their activity must be at once carried away to the metabolic or excretory tissues. And so with all the other tissues. There must be a free and speedy intercourse of material between each and all. This is at once and most easily effected by the regular circulation of a common fluid, the blood, into which all the elaborated food is discharged, from which each tissue seeks what it needs, and to which each returns that for which it has no longer any use. Such a circulation of fluid being in large measure a mechanical matter, needs a machinery, and calls forth an expenditure of energy. The machinery is supplied by a special construction of the primary tissues, and the energy is arranged for by the presence among these of contractile and irritable matter. Thus, to the fundamental tissues there is added, in the higher animals, a vascular bond in the shape of a mechanism of circulation.

In the second place, no less important than the interchange of material is the interchange of energy. In the amœba, the irritable surface is physiologically continuous with the more internal protoplasm, while each and every part of the body has automatic powers. In the higher animals portions only of the skin remain as eminently irritable or sensitive structures, while automatic actions are chiefly confined to a central mass of irritable or nervous matter. Both forms of irritable matter are separated by long tracts of indifferent material from those contractile tissues through which they chiefly manifest the changes going on in themselves. Hence the necessity for long strands of eminently irritable tissue to connect the skin and contractile tissues, as well with each other as with the automatic centres. Similar strands are also needed, though perhaps less urgently, to connect the other tissues with these and with each other. To the vascular bond there must be added an irritable bond, along the strands of which impulses, set up by changes in one or another part, may travel in determinate courses for the regulation of the energy of distant spots. In other words, part of the irritable tissues must be specially arranged to form a coördinating nervous system.

Still further complications have yet to be considered. In the life of a minute homogeneous amœba, possessing no special form or structure, there is little scope for purely mechanical operations. As, how-

ever, we trace out the gradual development of the more complex animal forms, we see coming forward into greater and greater prominence the arrangement of the tissues in definite ways to secure mechanical ends. Thus the entire body acquires particular shapes, and parts of the body are built up into mechanisms, the actions of which are to the advantage of the individual. Into the composition of these mechanisms, or "organs," the active, fundamental tissues, as well as the passive or indifferent tissues, enter; and the working of each mechanism, the function of each organ is dependent partly on the mechanical conditions offered by the passive elements, partly on the activity of the active elements. The vascular mechanism, of which we have just spoken, is such a mechanism. Similarly, the urgent necessity for the access of oxygen to all parts of the body has given rise to a complicated respiratory mechanism; and the needs of copious alimentation, to an alimentary or digestive mechanism.

Further, inasmuch as muscular movement is one of the chief ends, or the most important means to the chief ends of animal life, we find the animal body abounding in motor mechanisms, in which the prime mover is muscular contraction, while the machinery is supplied by complicated arrangements of muscles with such indifferent tissues as bone, cartilage, and tendon. In fact, the greater part of the animal body is a collection of muscular machines, some serving for locomotion, others for special manœuvres of particular members and parts, others as an assistance to the senses, and yet others for the production of voice, and, in man, of speech.

Lastly, the simple automatism of the amœba, with its simple responses to external stimuli, is replaced in the higher animals by an exceedingly complex volition, affected in multitudinous ways by influences from the world without; and there is a correspondingly complex central nervous system. And here we meet with a new form of differentiation unknown elsewhere. While the contractility of the amœbal protoplasm differs at the most but slightly from the contractility of the vertebrate striated muscle, there is an enormous difference between the simple irritability of the amœba and the complex action of the vertebrate nervous system. Excepting the nervous or irritable tissues, the fundamental tissues have in all animals exactly the same properties, being, it is true, more acute and perfect in one than in another, but remaining fundamentally the same. The elementary muscular fibre of a mammal is at most a mass of but slightly differentiated protoplasm, forming a whole physiologically continuous, and in no way constituting a mechanism. Each fibre is a counterpart of all others; and the muscle of one animal differs from that of another in such particulars only as are wholly subordinate. In the nervous tissues of the higher animal, on the contrary, we find properties unknown to those of the lower ones; and, in proportion as we ascend the scale, we observe an increasing differentiation of the nervous sys-

tem into unlike parts. Thus we have what does not exist in any other tissue—a mechanism of nervous tissue itself, a central nervous mechanism of complex structure and complex function, the complexity of which is due not primarily to any mechanical arrangement of its parts, but to the further differentiation of that fundamental quality of irritability and spontaneity which belongs to all irritable tissues and to all native protoplasm.

In the following pages I propose to consider the facts of physiology very much according to the views which have been just sketched out. The fundamental properties of most of the elementary tissues will first be reviewed, and then the various special mechanisms. It will be found convenient to introduce early the account of the vascular mechanism, and of its nervous, coördinating mechanism, while the mechanisms of respiration and alimentation will be best considered in connection with the respiratory and secretory tissues. The description of the purely motor mechanisms will be brief, and, save in a few instances, confined to a statement of general principles. The special functions of the central nervous system, including the senses, must of necessity be considered by themselves. The tissues and mechanism of reproduction naturally form the subject of the closing chapter.

THE ELECTRIC CANDLE.[1]

By ALFRED NIAUDET.

PUBLIC attention has been directed to Jabloshkoff's system of electrical lighting by the use that has been made of it at the Magasins du Louvre, in illuminating a hall recently opened. During the past year this invention was brought under the notice of the public by a communication addressed to the Paris Academy of Sciences, and by an experiment made before the Physical Society. The readers of *La Nature* are acquainted with the usual methods of producing electrical light, and we here again explain their general principles, with a view to render more intelligible the comparisons we propose to make.

Two carbon-points, borne on suitable metallic supports, are arranged in one line, with their tips in contact. An electric current of high intensity is made to pass into them; they may become heated, but they will not give out light unless they be separated by a little distance from each other. On separating them, by the hand or otherwise, the voltaic arc appears and gives out a very strong light. This light persists, provided the carbons are a few millimetres apart; but,

[1] Translated from the French by J. Fitzgerald, A. M.

as the carbons waste away, the distance between their tips becomes greater, the voltaic arc is lengthened, and soon the light goes out, unless the points are again brought near to each other. Hence it is seen that this rudimentary apparatus cannot support the electric light for over a few minutes, and some contrivance had to be devised for approximating the carbons in proportion as they waste away, and for keeping them a very small distance apart. This is done in the lamps devised by Serrin, Foucault, and others.

When the source of electricity is a pile or a magneto-electric machine with continuous currents, like Gramme's machine, a new difficulty is met with; for here the two carbons are consumed unequally, the positive one wasting about twice as fast as the negative. On the other hand, machines with alternately reversed currents present this peculiarity, that in them the waste of the two carbons is equal.

To whatever grade of perfection such lamps may have attained, they undoubtedly labor under sundry disadvantages. Their mechanism is delicate, and necessitates very great care on the part of those who operate them. It is not very easy to regulate them. Their main bulk, being situated beneath the luminous point, casts an objectionable shadow. As usually constructed, their size is such that they cannot work over three hours without having fresh carbons put in, and this renewal of the carbons necessitates either a temporary interruption of the lighting or else the keeping of an extra machine, which involves an increased outlay of money. Finally, the price of such machines is pretty high, and can hardly be reduced.

The very great progress made during the last few years in the construction of magneto-electric machines has made more evident the imperfections of the regulating apparatus.

Such was the condition of things when a Russian engineer, M. Jabloshkoff, succeeded in dispensing altogether with the mechanism of electrical lamps. Let us see how this lucky inventor has succeeded in overcoming the difficulties that successively arose before him.

First of all, he sets out with the idea that the carbons must be placed side by side, so as to consume them simultaneously without having continually to regulate their respective positions, just as in stearine-candles the wick is consumed in proportion to the consumption of stearine. The first requisite is, that the voltaic arc shall be produced only at the tips of the carbons. For this purpose it is sufficient to place between the two carbons a strip of glass, kaolin, or any other insulating substance, somewhat wider than the carbons, and not reaching to their tips. It might be supposed that this insulating substance, while separating the two carbons, would soon form an impassable barrier between the one and the other, and extinguish the voltaic arc by requiring it to make too great a span. But such is not the case; the high temperature of the voltaic arc is

sufficient to melt and even to vaporize glass or kaolin, and thus the insulating septum between the carbons wears away simultaneously with them.

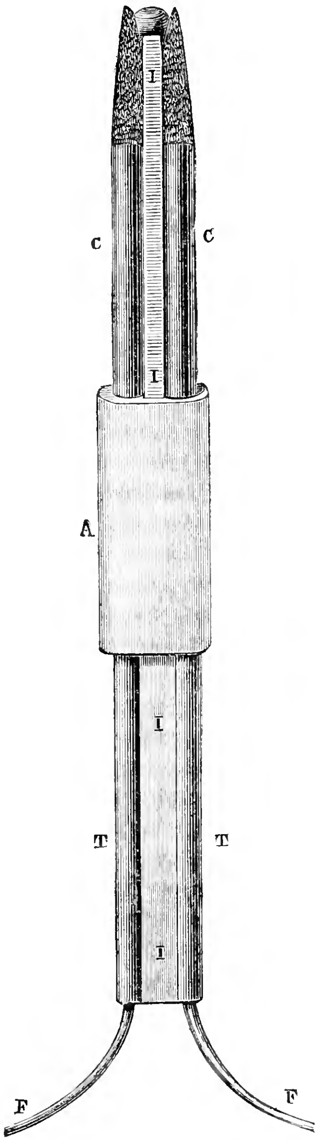
If the source of electricity gives constant currents, then, inasmuch as the carbons wear unequally, one wasting more rapidly than the other, the distance between the points will become too great, and the light will be extinguished. To overcome this difficulty, we have only to make the carbon that burns most rapidly twice as thick as the other.

It is true that hitherto the electric candle has worked better with magneto-electric machines giving alternating currents, than with piles or Gramme machines ; in the former case the carbons wear away equally, and are of the same thickness.

To complete the description of Jabloshkoff's apparatus, we have to add that each carbon is socketed in a brass tube, connected with a wire coming from the source of electricity. These two tubes are attached to each other in various ways, according to the applications had in view ; the one essential precaution is, to take care that they do not come into contact with each other.

The name candle has been very happily applied to this simple apparatus ; it is, indeed, a candle with two wicks burning side by side, and which lower their luminous point as combustion goes on. One interesting peculiarity it possesses, namely, that the luminous point can be turned downward, so that there is nothing to throw a shadow. Its light may be modified by the use of opal or ground-glass shades.

How the Candle is lighted.—One of the principal advantages of Serrin's lamp is, that it can be lighted from a distance. The lamp is made ready, say, in the morning, and, when night comes, all that is required is to admit the elec-



Jabloshkoff's Electric Candle (actual size).—*C C*, carbon-points of gas-coke ; *I I I I*, insulating substance ; *T T*, tubes holding the carbon-points ; *A*, socket of asbestos holding the system together ; *F F*, copper wires conveying the electric current.

tric current, and light is instantaneously produced. At first Jabloshkoff lighted his candle directly by supporting on the tips of the two wicks a piece of charcoal which he soon afterward removed; thus the voltaic arc was produced as in electric lamps, by beginning with contact, and then placing the two carbons at the required distance from each other. But it was necessary to devise some method for lighting the candle from a distance, and this fresh difficulty M. Jabloshkoff has overcome by a very simple device. He places between the two carbons a little bit of graphite, of the diameter used in lead-pencils; this acts as a conductor between the two wicks of the candle. On the current entering it, the bit of graphite soon becomes red-hot, and is burned up; there is then a break of continuity between the wicks, and the electric arc is produced. Instead of graphite, a fine metallic wire, or a bit of lead, can be used.

Relighting.—As we have stated, the insulating strip between the wicks is fused at the points near the voltaic arc, and so disappears gradually in proportion to the waste of the carbon-points. But this fusion of the insulator is attended with another consequence that but few of our readers would have anticipated. That which in its solid state is an insulator becomes in its liquid state a conductor, and allows of a longer span of the electric arc than could be had in the free air. Owing to this conductivity of the strip of kaolin, the circuit may be opened for a moment and the candle lighted again without any need of resorting to any of the contrivances already described under the head of "Lighting." But after a certain length of time, as the substance cools, it loses its conductivity, and then the candle cannot be relighted by simply closing the circuit again. We may extinguish the candle for nearly two seconds, and relight it by simply closing the circuit. Hence the electric candle may be used for transmitting telegraphic signals according to the Morse alphabet, by means of flashes of greater or less duration, divided by longer or shorter periods of eclipse. For such use the candle is better adapted than the electric lamp, as it is more readily relighted, producing at once a perfect voltaic arc, whereas in the lamp the arc is produced gradually.

Division of the Light.—Hitherto a separate pile, or a separate machine, has been necessary for the production of each electric light, and it has been found impossible to place two lamps in one circuit. This is readily understood when we consider the mechanism of the regulating apparatus. In electric lamps the approximation and the separating of the carbons are controlled by an electro-magnet, which itself follows the variations of resistance in the circuit produced by changes in the length of the voltaic arc. As the arc lengthens the resistance of the circuit is increased, and the electro-magnet is weakened, and allows the carbons to approximate. It is easily understood that if there are two lamps and two voltaic arcs in one circuit, and if only one of these arcs is lengthened, both electro-magnets will act and

shorten the two voltaic arcs. The consequence is, that the second lamp will have its proper working interfered with, while the first alone should have been regulated. In other words, the solidarity of the two apparatuses will tend to produce in each unnecessary changes of regulation that will constantly result in causing the system of lamps to work badly. But with the candle there is nothing of this kind, and, provided that the source of electricity possesses sufficient tension to produce the voltaic arcs, many may stand in the same circuit. In the Magasins du Louvre we have seen in some instances four lights, in others three, produced by a single machine. The sequel will show whether we can reasonably expect to see even a greater division of the electric light, and whether this invention may not have still further applications.—*La Nature.*

THE STATUS OF WOMEN AND CHILDREN.

By HERBERT SPENCER.

I.

PERHAPS in no way is the moral progress of mankind more clearly shown than by contrasting the position of women among savages with their position among the most advanced of the civilized: at the one extreme a treatment of them cruel to the utmost degree bearable; and at the other extreme a treatment which, in certain directions, gives them precedence over men.

The only limit to the brutality women are subjected to by men of the lowest races is the inability to live and propagate under greater. Clearly, ill-usage, under-feeding, and overworking, may be pushed to an extent which, if not immediately fatal to the women, incapacitates them for rearing children enough to maintain the population; and disappearance of the society follows. Both directly and indirectly such excess of harshness disables a tribe from holding its own against other tribes; since, besides greatly augmenting the mortality of children, it causes inadequate nutrition, and therefore imperfect development, of those which survive. But, short of this, there is at first no check to the tyranny which the stronger sex exercises over the weaker. Stolen from another tribe, and perhaps made insensible by a blow that she may not resist; not simply beaten, but speared about the limbs, when she displeases her savage owner; forced to do all the drudgery and bear all the burdens, while she has to care for and carry about her children; and feeding on what is left after the man has done: the woman's sufferings are carried as far as consists with survival of herself and her offspring.

It seems not improbable that, by its actions and reactions, this

treatment makes these relations of the sexes difficult to change; since chronic ill-usage produces physical inferiority, and physical inferiority tends to exclude those feelings which might check ill-usage. Very generally among the lower races the females are even more unattractive in aspect than the males. It is remarked of the Puttooahs, whose men are diminutive and whose women are still more so, that "the men are far from being handsome, but the palm of ugliness must be awarded to the women. The latter are hard-worked and apparently ill-fed." Again, of the inhabitants of the Corea, Gutzlaff says: "The females are very ugly, while the male sex is one of the best formed of Asia . . . . women are treated like beasts of burden; wives may be divorced under the slightest pretense." And for the kindred contrast habitually found, a kindred cause may habitually be assigned; the antithetical cases furnished by such uncivilized peoples as the Calmucks and Kirghiz, whose women, less hardly used, are better looking, yielding additional evidence.

We must not, however, conclude, as at first sight seems proper, that this low *status* of women among the rudest peoples is caused by a callous selfishness existing in the males and not equally present in the females. When we learn that where torture of enemies is the custom, the women outdo the men—when we read of the cruelties perpetrated by the two female Dyak chiefs described by Rajah Brooke, or of the horrible deeds which Winwood Reade narrates of a bloodthirsty African queen—we are shown that it is not lack of will but lack of power which prevents primitive women from displaying natures equally brutal with those of primitive men. A savageness common to the two necessarily works out the results we see under the conditions. Let us look at these results more closely.

Certain anomalies may first be noticed. Even among the rudest men, whose ordinary behavior to their women is of the worst, predominance of women is not unknown. Snow says of the Fuegians that he has "seen one of the oldest women exercising authority over the rest of her people;" and Mitchell says of the Australians that old men and even old women exercise great authority. Then we have the fact that among various peoples who hold their women in degraded positions, there nevertheless occur female rulers; as among the Batta people in Sumatra, as in Madagascar, and as in the above-named African kingdom. Possibly this anomaly results from the system of descent in the female line. For though, under that system, property and power usually devolve upon a sister's male children, yet as, occasionally, there is only one sister, and she has no male children, the elevation of a daughter may sometimes result. Even as I write, I find, on looking into the evidence, a significant example. Describing the Haidahs of the Pacific States, Bancroft says: "Among nearly all of them rank is nominally hereditary, for the most part by the female line. . . . Females often possess the right of chieftainship."

But leaving these exceptional facts, and looking at the average facts, we find these to be just such as the greater strength of men must produce, during stages in which the race has not yet acquired the higher sentiments. Numerous examples, already cited, show that at first women are regarded by men simply as property, and continue to be so regarded through several later stages: they are valued as domestic cattle. A Chippewayan chief said to Hearne:

> "Women were made for labor; one of them can carry, or haul, as much as two men can do. They also pitch our tents, make and mend our clothing, keep us warm at night; and, in fact, there is no such thing as traveling any considerable distance, in this country, without their assistance."

And this is the conception usual not only among peoples so low as these, but among peoples considerably advanced. To repeat an illustration quoted from Barrow, the woman "is her husband's ox, as a Caffre once said to me—she has been bought, he argued, and must therefore labor;" and to the like effect is Shooter's statement that a Caffre who kills his wife "can defend himself by saying, 'I have bought her once for all.'"

As implied in such a defense, the obtainment of wives by abduction or by purchase maintains this relation of the sexes. A woman of a conquered tribe, not killed but brought back alive, is naturally regarded as an absolute possession; as is also one for whom a price has been paid. Commenting on the position of women among the Chibchas, Simon writes, "I think the fact that the Indians treat their wives so badly and like slaves is to be explained by their having bought them." Fully to express the truth, however, we must rather say that the state of things, moral and social, implied by the traffic in women, is the original cause; since the will and welfare of a daughter are as much disregarded by the father who sells her as by the husband who buys her. The accounts of these transactions, in whatever society occurring, show this. Describing the sale of his daughter by a Mandan, Catlin says it is "conducted on his part as a mercenary contract entirely, where he stands out for the highest price he can possibly command for her." Of the ancient Yucatanese we read that "if a wife had no children, the husband might sell her, unless her father agreed to return the price he had paid." In East Africa, a girl's "father demands for her as many cows, cloths, and brass-wire bracelets, as the suitor can afford. . . . The husband may sell his wife, or, if she be taken from him by another man, he claims her value, which is ruled by what she would fetch in the slave-market." Of course, where women are exchangeable for oxen or other beasts, they are regarded as equally without personal rights.

The degradation they are subject to during phases of human evolution in which egoism is unchecked by altruism, is, however, most vividly shown by the transfer of a deceased man's wives to his rela-

tives along with other property. Sundry examples of this have been given; and many others might be added. Smith says of the Mapuchès that "a widow by the death of her husband becomes her own mistress, unless he may have left grown-up sons by another wife, in which case she becomes their common concubine, being regarded as a chattel naturally belonging to the heirs of the estate."

Thus recognizing the truth that as long as women continue to be stolen or bought, their human individualities are ignored, let us observe the division of labor that results between the sexes; determined partly by this unqualified despotism of men and partly by the limitations which certain incapacities of women entail.

The slave-class in a primitive society consists of the women; and the earliest division of labor is that which arises between them and their masters. For a long time no other division of labor exists. Of course nothing more is to be expected among such low, wandering groups as Tasmanians, Australians, Fuegians, Andamanese, Bushmen. Nor do we find any advance in this respect made by the higher hunting races, such as the Comanches, Chippewas, Dakotas, etc.

Of the occupations thus divided, the males put upon the females whatever these are not disabled from doing by inadequate strength, or agility, or skill. While the men among the now-extinct Tasmanians added to the food only that furnished by the kangaroos they chased, the women climbed trees for opossums, dug up roots with sticks, groped for shell-fish, dived for oysters, and fished, in addition to looking after their children; and there now exists a kindred apportionment among the Fuegians, Andamanese, Australians. Where the food consists wholly or mainly of the greater mammals, the men catch and the women carry. We read of the Chippewas that "when the men kill any large beast, the women are always sent to bring it to the tent;" of the Comanches, that the women "often accompany their husbands in hunting—he kills the game, they butcher and transport the meat, dress the skins, etc.;" of the Esquimaux, that when the man has "brought his booty to land, he troubles himself no further about it; for it would be a stigma on his character, if he so much as drew a seal out of the water." Though, in these cases, an excuse made is that the exhaustion caused by the chase is great, yet, when we read that the Esquimaux women, excepting the woodwork, "build the houses and tents, and though they have to carry stones almost heavy enough to break their backs, the men look on with the greatest insensibility, not stirring a finger to assist them," we cannot accept the excuse as adequate. Further, it is the custom with these low races, nomadic or semi-nomadic in their habits, to give the females the task of transporting the baggage. A Tasmanian woman often had piled on all the other burdens she carried when tramping, "sundry spears and waddies not required for present service;" and the like

happens with races considerably higher, both semi-agricultural and pastoral. A Damara's wife "carries his things when he moves from place to place." When the Tupis migrate, all the household stock is taken to the new abode by the females: "The husband only took his weapons, and the wife," says Marcgraff, "is loaded like a mule." Similarly, enumerating the labors of wives among the aborigines of South Brazil, Spix and Martius say, "They are also the beasts of burden;" and in like manner Dobrizhoffer writes, "The luggage being all committed to the women, the Abipones travel armed with a spear alone, that they may be disengaged to fight or hunt, if occasion requires." Doubtless the reason indicated in the last extract is a partial defense for this practice, so general with savages when traveling; since, liable as they are to be at any moment surprised by ambushed enemies, fatal results would happen were the men not ready to fight on the instant. And possibly knowledge of this may join the force of custom in making the women themselves uphold the practice, as they do.

On ascending to societies partially or wholly settled, and a little more complex, we begin to find considerable diversities in the division of labor between the sexes. Usually the men are the builders, but not always: the women erect the huts among the Bechuanas, Caffres, Damaras, as also do the women of the Outanatas, New Guinea; and sometimes it is the task of women to cut down trees, though nearly always this business falls to the men. Anomalous as it seems, we are told of the Coroados that "the cooking of the dinner, as well as keeping in the fire, is the business of the men;" and the like happens in Samoa: "The duties of cooking devolve on the men"—not excepting the chiefs. Mostly among the uncivilized and semi-civilized, trading is done by the men, but not always. In Java, according to Raffles, "the women alone attend the markets and conduct all the business of buying and selling." So, too, according to Astley, in Angola the women "buy, sell, and do all other things which the men do in other countries, while their husbands stay at home, and employ themselves in spinning, weaving cotton, and such like effeminate business." In ancient Peru there was a like division: men did the spinning and weaving, and women the field-work. Again, according to Bruce, in Abyssinia "it is infamy for a man to go to market to buy anything. He cannot carry water or bake bread; but he must wash the clothes belonging to both sexes, and, in this function, the women cannot help him." And Petherick says that among the Arabs "the females repudiate needlework entirely, the little they require being performed by their husbands and brothers."

From a general survey of the facts, multitudinous and heterogeneous, thus briefly indicated, the only definite conclusion appears to be that men monopolize the occupations requiring both strength and agility always available—war and the chase. Leaving undiscussed the relative fitness of women at other times for fighting enemies and

pursuing wild animals, it is clear that during the child-bearing period their ability to do either of these things is so far interfered with, both by pregnancy and by the suckling of infants, that they are practically excluded from them. Though the Dahomans, with their army of amazons, show us that women may be warriors, yet the instance proves that women can become warriors only by being practically unsexed; for, nominally wives of the king, they are celibate, and any unchastity is fatal. But omitting those activities for which women are, during large parts of their lives, physically incapacitated, or into which they cannot enter in considerable numbers without fatally diminishing population, we cannot define the division of labor between the sexes, further than by saying that, before civilization begins, the stronger sex forces the weaker to do all the drudgery; and that along with social advance the apportionment, somewhat mitigated in character, becomes variously specialized under varying conditions.

As bearing on the causes of the mitigation, presently to be dealt with, we may here note that women are better treated where circumstances lead to likeness of occupations between the sexes. Schoolcraft remarks of the Chippewayans that "they are not remarkable for their activity as hunters, which is owing to the ease with which they snare deer and spear fish, and these occupations are not beyond the strength of their old men, women, and boys;" and then he also says that "though the women are as much in the power of the men as other articles of their property, they are always consulted, and possess a very considerable influence in the traffic with Europeans, and other important concerns." We read, too, in Lewis and Clarke, that "among the Clatsops and Chinnooks, who live upon fish and roots, which the women are equally expert with the men in procuring, the former have a rank and influence very rarely found among Indians. The females are permitted to speak freely before the men, to whom, indeed, they sometimes address themselves in a tone of authority." Then, again, Bancroft tells us that "in the province of Cueba women accompany the men, fighting by their side and sometimes even leading the van;" and of this same people he also quotes Wafer as saying that "their husbands are very kind and loving to them. I never knew an Indian to beat his wife, or give her any hard words." A kindred meaning appears traceable in a fact supplied by the Dahomans, among whom, sanguinary and utterly unfeeling as they are, the participation of women with men in war goes along with a social *status* much higher than usual; for Burton tells us that in Dahomey "the woman is officially superior, but under other conditions she still suffers from male arrogance."

A probable further cause of improvement in the treatment of women may here be noted: I refer to the obtaining of wives by services rendered, instead of by property paid. The practice which Hebrew tradition acquaints us with in the case of Jacob, proves to be a

widely-diffused practice. It is general with the Bhils, Gonds, and Hill-tribes of Nepaul; it obtained in Java before Mohammedanism was introduced; it was common in ancient Peru and Central America; and among sundry existing American races it still occurs. Obviously, a wife long labored for is likely to be more valued than one stolen or bought. Obviously, too, the period of service, during which the betrothed girl is looked upon as a future spouse, affords room for the growth of some feeling higher than the merely instinctive—initiates something approaching to the courtship and engagement of civilized peoples. But the facts chiefly to be noted are—1. That this modification, practicable with difficulty among the rudest predatory tribes, becomes gradually more practicable as there arise established industries affording spheres in which services may be rendered; and, 2. That it is the poorer members of the community, occupied in labor and unable to buy their wives, among whom the substitution of service for purchase will most prevail; the implication being that this higher form of marriage into which the industrial class is led, develops along with the industrial type.

And now we are introduced to the general question, "What connection is there between the *status* of women and the type of social organization?"

A partial answer to this question was reached when we concluded that there are natural associations between militancy and polygyny, and between industrialness and monogamy. For, as polygyny implies a low position of women, while monogamy is a prerequisite to a high position of women, it follows that decrease of militancy and increase of industrialness are general concomitants of a rise in their position. This conclusion appears also to be congruous with the fact just observed. The truth that, among peoples otherwise inferior, the position of women is relatively good where their occupations are nearly the same as those of men, seems allied to the wider truth that their position becomes good in proportion as warlike activities are replaced by industrial activities; since, when the men fight while the women work, the difference of occupation is greater than when both are engaged in productive labors, however unlike such labors may be in kind. From general reasons for alleging this connection, let us now pass to more special reasons.

As it needed no marshaling of evidence to prove that the chronic militancy characterizing low, simple tribes, habitually goes with polygyny, so it needs no marshaling of evidence to prove that along with this chronic militancy there goes a brutal treatment of women. It will suffice if we here glance at the converse cases of simple tribes which are exceptional in their industrialness, and at the same time exceptional in the higher positions held by women among them. Even the rude Todas, low as are the sexual relations implied by their com-

bined polyandry and polygyny, and little developed as is the industry implied by their semi-settled cow-keeping life, furnish evidence: to the men and boys are left all the harder kinds of work, and the wives "do not even step out-of-doors to fetch water or wood, which . . . . is brought to them by one of their husbands;" and this trait goes along with the trait of peacefulness and entire absence of the militant type of social structure. Striking evidence is furnished by another of the Hill-tribes—the Bodo and Dhimáls. We have seen that, among peoples in low stages of culture, these furnish a marked case of non-militancy, absence of the political organization which militancy develops, absence of class-distinctions, and presence of that voluntary exchange of services implied by industrialism; and of them, monogamous as already shown, we read: "The Bodo and Dhimáls use their wives and daughters well; treating them with confidence and kindness. They are free from all out-door work whatever." Take, again, the Dyaks, who, though not without tribal feuds and their consequences, are yet without stable chieftainships and military organization, are predominantly industrial, and have rights of individual property well developed. Though among the varieties of them the customs differ somewhat, yet the general fact is that the heavy out-door work is mainly done by the men, while the women are generally well treated, and have considerable privileges. With their monogamy goes regular courtship, and the girls choose their mates; St. John says of the Sea Dyaks that "husbands and wives appear to pass their lives very agreeably together;" and Rajah Brooke names Mukah as a part of Borneo where the wives close their doors, and will not receive their husbands unless they procure fish. Then, as a marked case of a simple community having relatively high industrial organization, with elective head, representative council, and the other concomitants of the type, and who are described as "industrious, honest, and peace-loving," we have the Pueblos, who, with that monogamy which characterizes their family relations, also show us a remarkably high *status* of women. For among them not simply is there courtship, and choice exercised by girls; not simply do we read that "no girl is forced to marry against her will, however eligible her parents may consider the match;" but sometimes, according to Bancroft, "the usual order of courtship is reversed; when a girl is disposed to marry she does not wait for a young man to propose to her, but selects one to her own liking and consults her father, who visits the parents of the youth and acquaints them with his daughter's wishes."

On turning from simple societies to compound societies, we find two adjacent ones in Polynesia exhibiting a strong contrast between their social types as militant and industrial, and an equally strong contrast between the positions they respectively give to women: I refer to Feejeeans and Samoans. The Feejeeans show us the militant structure, actions, and sentiments, in extreme forms. Under an un-

mitigated despotism there are fixed ranks, obedience the most profound, marks of subordination amounting to worship; there is an organized military system with its grades of officers; the lower classes exist only to supply necessaries to the warrior-classes, whose sole business is war, merciless in its character and accompanied by cannibalism. And here, along with prevalent polygyny, carried among the chiefs to the extent of from ten to a hundred wives, we find the position of women such that, not only are they, as among the lowest savages, "little better than beasts of burden," and not only may they be sold at pleasure, but a man may kill and eat his wife if he pleases. Contrariwise, in Samoa the type of the regulating system has become in a considerable degree industrial. There is representative government, and chieftains, exercising authority under considerable restraint, are partly elective; while the industrial organization is so far developed that there are journeymen and apprentices, there is payment for labor, and there are even strikes, with a rudimentary trades-unionism. And here, beyond that improvement of women's *status* implied by limitation of their labors to the lighter kinds while men take the heavier, there is the improvement implied by the fact that "the husband has to provide a dowry, as well as the wife, and the dowry of each must be pretty nearly of equal value," and by the fact that a couple who have lived together for years make, at separation, a fair division of the property. Of other compound societies fit for comparison, I may name two in America, North and South, the Iroquois and the Araucanians. Though these, alike in degree of composition, were both formed by combination in war against civilized invaders, yet, in their social structures, they differed in the respect that the Araucanians became decidedly militant in their regulative organization, while the Iroquois did not give their regulative organization the militant form; for the governing agencies, general and local, were in the one personal and hereditary and in the other representative. Now, though these two peoples were much upon a par in the division of labor between the sexes—the men limiting themselves to war, the chase, and fishing, leaving to the women the labors of the field and the house—yet along with the freer political type of the Iroquois there went a freer domestic type; as shown by the facts that the women had separate proprietary rights, that they took with them the children in cases of separation, and that marriages were arranged by the mothers. No definite evidence either way is furnished by the doubly-compound societies of ancient America. The political organization of Mexico was in a high degree militant in type; but along with it there went an elaborate industrial organization, with extensive division of labor and considerable commercial intercourse; and, excepting in the polygyny and concubinage of the upper classes, and occasional inheritance of wives as property, the position of women appears to have been not bad. The Peruvian

nation, which, though less sanguinary in its observances, had the militant structure carried out far more completely, so that its industrial organization formed part of the political organization, gave a lower *status* to women, who did the hard work, and who, in the upper ranks at least, had to sacrifice themselves on the deaths of their husbands.

The highest societies, ancient and modern, are many of them rendered in one way or other unfit for comparisons. In some cases the evidence is inadequate; in some cases we know not what the antecedents have been; in some cases the facts have been confused by agglomeration of different societies; and in all cases the coöperating influences have increased in number. Concerning the most ancient ones, of which we know least, we can do no more than say that the traits presented by them are not inconsistent with the view here set forth. The Accadians, who before reaching that height of civilization at which phonetic writing was achieved, must have existed in a settled populous state for a vast period, must have therefore had for a vast period a considerable industrial organization; and it seems not improbable that during such period, being powerful in comparison with wandering tribes around, their social life, little perturbed by enemies, was substantially peaceful. Hence there is no incongruity in the fact that they are shown by their records to have given their women a relatively high *status:* wives owned property, and the honoring of mothers was especially enjoined by their laws. Of the Egyptians something similar may be said. Their earliest wall-paintings show us a people far advanced in arts, industry, observances, mode of life. The implication is irresistible that, before the stage thus depicted, there must have been a long era of rising civilization; and since this era was passed in an isolated fertile tract, mostly surrounded by such nomadic hordes only as the deserts could support, the Egyptians were relatively strong, and may not improbably have long led a life largely industrial. So that, though the militant type of social structure evolved during the time of their consolidation, and made sacred by their form of religion, continued, yet industrialism must have become an important factor, influencing greatly their social arrangements, and diffusing its appropriate sentiments and ideas. And the position of woman was relatively good. Though polygyny existed, it was unusual; matrimonial regulations were strict, and divorce difficult; "married couples lived in full community;" women shared in social gatherings as they do in our own societies; in sundry respects they had precedence given to them; and, in the words of Ebers, "many other facts might be added to prove the high state of married life."

Ancient Aryan societies illustrate well the relationship between the domestic *régime* and the political *régime*. The despotism of an irresponsible head, which characterizes the militant type of structure, characterized alike the original patriarchal family, the cluster of fami-

lies having a common ancestor, and the united clusters of families forming the early Aryan community. As Mommsen describes him, the early Roman ruler, once in office, stood toward citizens in the same relation that the father of the family did to wife, children, and slaves: "The regal power had not, and could not have, any external checks imposed upon it by law: the master of the community had no judge of his acts within the community, any more than the house-father had a judge within his household. Death alone terminated his power." From this first stage, in which the political head was absolute, and absoluteness of the domestic head went to the extent of life and death power over his wife, the advance toward a higher *status* of women was doubtless, as Sir Henry Maine contends, largely caused by that disintegration of the family which went along with the progressing union of smaller societies into larger ones effected by conquest. But though successful militancy thus furthered female emancipation, it did so only by thereafter reducing the relative amount of militancy; and the emancipation was really associated with an average increase of industrial structures and activities. As before pointed out, militancy is to be measured not so much by success in war as by the extent to which it occupies the male population. Where all men are warriors, and the work is done entirely by women, militancy is the greatest. The introduction of a class of males who, joining in productive labor, lay the basis for an industrial organization, qualifies the militancy. And as the industrial class, at first consisting though it does wholly of slaves, increases in proportion to the militant class, the total activities of the society must be regarded as more industrial and less militant. In another way the same truth is implied, if we consider that when a number of small hostile societies are consolidated by triumph of the stronger, the amount of fighting throughout the area occupied becomes less, although the conflicts now from time to time arising with neighboring larger aggregates may be on a greater scale. This is clearly seen on comparing the ratio of fighting-men to population among the early Romans with the ratio between the armies of the empire and the number of people included in the empire. And there is the further fact that the holding together of these compound and doubly-compound societies eventually formed by conquest, and the efficient coöperation of their parts for military purposes, itself implies an increased development of the industrial organization. Great armies carrying on operations at the periphery of a great territory, imply a numerous working population, a considerable division of labor, and good appliances for transferring supplies: the sustaining and distributing systems must be well developed before large militant structures can be worked. So that this disintegration of the patriarchal family, and consequent emancipation of women, which went along with growth of the Roman Empire, really had for its concomitant a development of the industrial organization.

In other ways a like relation of cause and effect is shown us during the progress of European societies since Roman times.

Respecting the *status* of women in mediæval Europe, Sir Henry Maine says:

> "There can be no serious question that, in its ultimate result, the disruption of the Roman Empire was very unfavorable to the personal and proprietary liberty of women. I purposely say 'in its ultimate result,' in order to avoid a learned controversy as to their position under purely Teutonic custom."

Now, leaving open the question whether this conclusion applies beyond those parts of Europe in which institutions of Roman origin were least affected by those of Germanic origin, we may, I think, on contrasting the condition of things before the fall of the empire and the condition after, infer a connection between this decline in the *status* of women and a return to greater militancy. For while Roman power held together the populations of large areas, there existed throughout them a state of comparative internal peace; whereas its failure to maintain subordination was followed by universal warfare: producing from time to time larger aggregates and again dissolutions of them, until the disintegration had reached the stage in which there existed numerous feudal governments mutually hostile. And then, after that decline in the position of women which accompanied this retrograde increase of militancy, the subsequent improvement in their position went along with aggregation of smaller feudal governments into larger ones, which had the result that within the consolidated territories the amount of diffused fighting decreased.

Comparisons between the chief civilized nations as now existing, yield verifications. Note, first, the fact, significant of the relation between political despotism and domestic despotism, that, according to Legouvé, Napoleon I. said to the Council of State, "Un mari doit avoir un empire absolu sur les actions de sa femme;" and that sundry provisions of the Code, as interpreted by Pothier, carry out this dictum. Further, note that, according to De Ségur, the position of women in France declined under the empire; and that "it was not only in the higher ranks that this nullity of women existed. . . . The habit of fighting filled men with a kind of contempt and asperity which made them often forget even the regard which they owed to weakness." Passing over less essential contrasts now presented by the leading European peoples, and considering chiefly the *status* as displayed in the daily lives of the poorer rather than the richer, it is manifest that the mass of women have harder lots where militant organization and activity predominate, than they have where there is a predominance of industrial organization and activity. The sequence observed by travelers in Africa, that in proportion as the men are occupied in war more labor falls on the women, is a sequence which both France and Germany show us. Social sustentation has to be

carried on; and necessarily the more males are drafted off for military service, the more females must be called on to fill their places as workers. Hence the extent to which in Germany women are occupied in rough, out-of-door tasks—digging, wheeling, carrying burdens; hence the extent to which in France heavy field-operations are shared in by women. That the English housewife is less a drudge than her German sister, that among shopkeepers in England she is not required to take so large a share in the business as she is among shopkeepers in France, and that in England the out-of-door work done by women is both smaller in quantity and lighter in kind, is clear; as it is clear that this difference is associated with a lessened demand on the male population for purposes of offense and defense. And then there may be added the fact of kindred meaning, that in the United States, where till the late war the degree of militancy had been so small, and the industrial type of social structure and action so predominant, women have reached a higher *status* than anywhere else.

Evidence furnished by existing Eastern nations, so far as it can be disentangled, supports this view. China, with its long history of wars causing consolidations, dissolutions, reconsolidations, etc., going back more than 2,000 years B. C., and continuing during Tartar and Mongol conquests to be militant in its activities and arrangements, has, notwithstanding industrial growth, retained the militant type of structure; and absolutism in the state has been accompanied by absolutism in the family, qualified in the one as in the other only by the customs and sentiments which industrialism has fostered: wives are bought; concubinage is common among those adequately well off; widows are sometimes sold as concubines by fahters-in-law; and women join in hard work, sometimes to the extent of being harnessed to the plough; while, nevertheless, this low *status* is practically raised by a public opinion that checks the harsh treatment legally allowable. Similarly Japan, which, passing through long periods of internal conflict ending in integration, acquired an organization completely militant, under which political freedom was unknown, showed a simultaneous absence of freedom in the household—buying of wives, concubinage, divorce at mere will of husband, crucifixion or decapitation for wife's adultery; while, along with the growth of industrialism characterizing the later days of Japan, there went such improvement in the legal *status* of women that the husband was no longer allowed to take the law into his own hands in case of adultery; and now, though women are occasionally seen using the flail, yet mostly the men, according to Sir Rutherford Alcock, "leave their women to the lighter work of the house, and perform themselves the harder out-door labor."

It is, of course, difficult to generalize phenomena into the genesis of which there enter factors so numerous and involved—character of

race, religious beliefs, surviving customs and traditions, degree of culture, etc.; and doubtless the many coöperating causes give rise to incongruities which qualify somewhat the conclusion drawn. But, on summing up the several arguments, we shall, I think, see that conclusion to be substantially true.

The least entangled evidence is that which most distinctly forces this conclusion upon us. Remembering that nearly all simple uncivilized societies, having chronic feuds with their neighbors, are militant in their activities, and that their women are extremely degraded in position, the fact that in the exceptional simple societies which are peaceful and industrial there is an exceptional elevation of women almost alone suffices as proof: neither race, nor creed, nor culture, being in these cases an assignable cause.

The connections which we have seen exist between militancy and polygyny, and between industrialness and monogamy, present the same truth under another aspect; since polygyny necessarily implies a low *status* of women, and monogamy, if it does not necessarily imply a high *status*, is an essential condition to a high *status*.

Further, that approximate equalization of the sexes in numbers which results from diminishing militancy and increasing industrialness, conduces to the elevation of women; since, in proportion as the supply of males available for carrying on social sustentation increases, the labor of social sustentation falls less heavily on the females. And it may be added that the societies in which the surplus of males thus made available undertakes the harder labors, and so, relieving the females from undue physical tax, enables them to produce more and better offspring, will, other things equal, gain in the struggle for existence with societies in which the women are not thus relieved by the men: whence an average tendency to the spread of societies in which the *status* of women is improved.

There is the fact, too, that the despotism distinguishing a community organized for war, is essentially connected with despotism in the household; while, conversely, the freedom which characterizes public life in an industrial community, naturally characterizes also the accompanying private life. In the one case compulsory coöperation prevails in both; in the other case voluntary coöperation prevails in both.

By the moral contrast we are shown another face of the same fact. Habitual antagonism with, and destruction of, foes, sears the sympathies; while daily exchange of products and services among citizens, puts no obstacle to increase of fellow-feeling. And the altruism which grows with peaceful coöperation, ameliorates at once the life without the household and the life within the household.[1]

[1] Too late to be inserted in its proper place, and so late that I have canceled stereotype plates to bring it in, I have met with a striking verification in the just-issued work of Mr. W. Mattieu Williams, F. R. A. S., F. C. S., "Through Norway with Ladies." He says, "There are no people in the world, however refined, among whom the relative posi-

II.

That brutes, however ferocious, treat their offspring tenderly, is a familiar fact; and that tenderness to offspring is shown by the most brutal of mankind, is a fact quite congruous with it. An obvious explanation of this seeming anomaly exists. As we saw that the treatment of women by men cannot pass a certain degree of harshness without causing extinction of the tribe, so, here, we may see that the tribe must disappear unless the love of progeny is strong. Hence we need not be surprised when Mouat tells us that the Andaman-Islanders "show their children the utmost tenderness and affection;" or when we read in Snow's account of the Fuegians that both sexes are much attached to their offspring; or when Sturt describes Australian fathers and mothers as behaving to their little ones with much fondness. Affection intense enough to prompt great self-sacrifice is, indeed, especially requisite under the conditions of savage life, which render the rearing of young difficult; and maintenance of such affection is insured by the dying out of families in which it is deficient.

But this strong parental love is, like the parental love of animals, very irregularly displayed. As among brutes the philoprogenitive instinct is occasionally suppressed by the desire to kill, and even to devour, their young ones, so, among primitive men, this instinct is now and again overridden by impulses temporarily excited. Thus, though attached to their offspring, Australian mothers, when in danger, will sometimes desert them; and, if we may believe Angas, men have been known to bait their hooks with the flesh of boys they have killed. Thus, notwithstanding their marked parental affection, Fuegians sell their children for slaves; thus, among the Chonos Indians, a father, though doting on his boy, will kill him in a fit of anger for an accidental offense. Everywhere among the lower races we meet with like incongruities. Falkner, while describing the paternal feelings of Patagonians as very strong, says they often pawn and sell their wives and little ones to the Spaniards for brandy. Speaking of the children of the Sound Indians, Bancroft says they "sell or gamble them away." According to Simpson, the Pi-Edes "barter their children to the Utes proper, for a few trinkets or bits of clothing." And of the Macusi, Schomburgk writes, "The price of a child is the same as the Indian asks for his dog."

This seemingly-heartless conduct to children often arises from the

tion of man and woman is more favorable to the latter than among the Lapps." After giving evidence from personal observation, he asks the reason, saying: "Is it because the men are not warriors? . . . They have no soldiers, fight no battles, either with outside foreigners, or between the various tribes and families among themselves. . . . In spite of their wretched huts, their dirty faces, their primitive clothing, their ignorance of literature, art, and science, they rank above us in the highest element of true civilization, the moral element; and all the military nations of the world may stand uncovered before them" (pp. 162, 163).

difficulty experienced in rearing them. To it the infanticide so common among the uncivilized and semi-civilized is, of course, mainly due —the burial of living infants with mothers who have died in childbirth; the putting to death one out of twins; the destruction of younger children when there are already several. For these acts there is an excuse like that commonly to be made for killing the sick and old. When, concerning the desertion of aged people by wandering prairie tribes, Catlin says, "It often becomes absolutely necessary in such cases that they should be left, and they uniformly insist upon it, saying, as this old man did, that they are old and of no further use, that they left their fathers in the same manner, that they wish to die, and their children must not mourn for them"—when, of the Nascopies, Heriot tells us that in his old age "the father usually employed as his executioner the son who is most dear to him"—when, in Kane, we read of the Assiniboin chief who "killed his own mother," because, being "old and feeble," she "asked him to take pity on her and end her misery"—there is suggested the conclusion that, as destruction of the ill and infirm may lessen the total amount of suffering to be borne under the conditions of savage life, so may the destruction of infants, when the region is barren or the mode of life so hard that the rearing of many is impracticable. And a like plea may be urged in mitigation of judgment on savages who sell or barter away their children: the needs of the younger ones possibly, in some cases, prompting this sacrifice of the elder.

Generally, then, among uncivilized peoples, as among animals, instincts and impulses are the sole incentives and deterrents. The *status* of a primitive man's child is like that of a bear's cub. There is neither moral obligation nor moral restraint; but there exists the unchecked power to foster, to desert, to destroy, as love or anger moves.

To the yearnings of natural affection are added in early stages of progress certain motives, partly personal, partly social, which help to secure the lives of children; but which, at the same time, initiate differences of *status* between children of different sexes. There is the desire to strengthen the tribe in war; there is the wish to have a future avenger on individual enemies; there is the anxiety to leave behind one who shall perform the funeral rites and continue oblations at the grave.

Inevitably, the urgent need to augment the number of warriors leads to preference for male children. On reading of such a militant race as the Chechemecas, that they "like much their male children, who are brought up by their fathers, but they despise and hate the daughters;" or of the Panches, that, when "a wife bore her first girl-child, they killed the child, and thus they did with all the girls born before a male child," we are shown the effect of this desire for sons; and

everywhere we find it leading either to destruction of daughters, or to low estimation and ill-treatment of them. Through long ascending stages of social life the desire thus arising persists; as instance the statement of Herodotus, that every Persian prided himself on the number of his sons, and it is even said that an annual prize was given by the monarch to the Persian who could show most sons living. Obviously the social motive, thus coming in aid of the parental motive, served to raise the *status* of male children above that of female.

A reason for the care of sons implied in the passage of Ecclesiasticus which says, "He left behind him an avenger against his enemies," is a reason which has weighed with all races in barbarous and semi-civilized states. The sacred duty of blood-revenge, earliest of recognized obligations among men, survives so long as societies remain predominantly warlike; and it generates an anxiety to have a male representative who shall retaliate upon those from whom injuries have been received. This bequest of quarrels to be fought out, traceable down to recent times among so-called Christians, as in the will of Brantôme, has, of course, all along raised the value of sons, and has so put upon the harsh treatment of them a check not put upon the harsh treatment of daughters—whence a further differentiation of *status*.

The development of ancestor-worship, which, enjoining sacrifices to be made by each man at the tombs of his immediate and more remote male progenitors, implies anticipation of like sacrifices to his own ghost by his son, initiates yet another motive for cherishing sons—adds to the parental regard for children a feeling which tells in favor of males rather than of females. The effects of this motive are at the present time shown us by the Chinese, among whom the death of an only son is especially lamented, because there will be no one to make offerings at the grave, and among whom the peremptory need for a son hence arising is held to justify the taking of a concubine, though, "if a person has sons by his wife (for daughters never enter into the account), it is considered derogatory to take a handmaid at all." On recalling Egyptian wall-paintings and papyri, and the like evidence furnished by Assyrian records, showing that sacrifices to ancestors were performed by their male descendant—on remembering, too, that among ancient Aryans, Hindoo, Greek, Roman, the daughter was incapable of this function, and that sons were, therefore, required for maintaining the family-cult—we are shown how this developed form of the primitive religion, while it strengthened filial subordination, added an incentive to parental care—of sons, but not of daughters.

In brief, then, the relations of adults to young among human beings, originally like those among animals, began to assume higher forms under the influence of the several desires—to obtain an aider in fighting enemies, to provide an avenger for injuries received, and to

leave behind one who should administer to welfare after death: motives which, strengthening as societies passed through their early stages, gradually gave a certain authority to the claims of male children, though not to those of females. And thus we again see how intimate is the connection between militancy of the men and degradation of the women.

Here we are introduced to the question, "What relation exists between the *status* of children and the form of social organization?" To this the reply is akin to one given in the last chapter; namely, that mitigation of the treatment of children accompanies transition from the militant type to the industrial type.

Those lowest social states in which offspring are now idolized, now killed, now sold, as the dominant feeling prompts, are everywhere the states in which hostilities with surrounding tribes are chronic. This absolute dependence of progeny on parental will is shown whether the militancy is that of archaic groups, or that of groups higher in structure. In the latter as in the former, there exists that life and death power over children which is the negation of all rights and claims. On comparing children's *status* in the rudest militant tribes with their *status* in militant tribes which are patriarchal and compounded of the patriarchal, all we can say is, that in these last the still-surviving theory becomes qualified in practice; and that qualification of it increases as industrialism grows.

The Feejeeans, intensely despotic in government, and ferocious in war, furnish an instance of extreme abjectness in the position of children. Infanticide, especially of females, reaches nearer two-thirds than one-half; they "destroy their infants from mere whim, expediency, anger, or indolence;" and, according to Erskine, "children have been offered by the people of their own tribe to propitiate a powerful chief," not for slaves but for food. A sanguinary warrior race of Mexico—the Chechemecas—yield another example of excessive parental power: sons "cannot marry without the consent of parents; if a young man violates this law . . . . the penalty is death." By this instance we are reminded of the domestic condition among the ancient Mexicans (largely composed of conquering cannibal Chechemecas), whose social organization was highly militant in type, and of whom Clavigero says, "Their children were bred to stand so much in awe of their parents, that even when grown up and married, they hardly durst speak before them." In ancient Central America family rule was similar; and in ancient Peru it was the law that "sons should obey and serve their fathers until they reached the age of twenty-five."

If we now turn to the few cases of uncivilized and semi-civilized societies that are wholly industrial, or predominantly industrial, we find children, as we found women, occupying much higher positions. Among the peaceful Bodo and Dhimáls, "infanticide is utterly un-

known;" daughters are treated "with confidence and kindness;" and when marriages are being arranged, "there is a consulting the destined bride;" to which add the reciprocal trait that "it is deemed shameful to leave old parents entirely alone." The Dyaks, again, largely industrial, and having an unmilitant social structure, yield the fact stated by Brooke, that "the practice of infanticide is rare," as well as the facts before named under another head, that children have the freedom implied by regular courtship, and that girls choose their mates. We are told of the Samoans, who are more industrial in social structure and habit than neighboring Malayo-Polynesians, that infanticide after birth is unknown, and that children have the degree of independence implied by elopements when they cannot obtain parental assent to their marriage. Similarly with the Negritos inhabiting the island of Tanna, where militancy is slight and there are no pronounced chieftainships: of them we read in Turner that "the Tannese are fond of their children. No infanticide there. They allow them every indulgence, girls as well as boys." Lastly, there is the case of the industrious Pueblos, whose children were unrestrained in marriage, and by whom, as we have seen, daughters were especially privileged.

Thus with a highly-militant type there goes extreme subjection of children, and the *status* of girls is still lower than that of boys; while in proportion as the type becomes non-militant, there is not only more recognition of children's claims, but the recognized claims of boys and girls approach toward equality.

Kindred evidence is supplied by those societies which, passing through the patriarchal forms of domestic and political government, have evolved into large nations. Be the race Turanian, Semitic, or Aryan, it shows us the same connection between political absolutism over subjects and domestic absolutism over children.

In China the destruction of female infants is common; "parents sell their children to be slaves;" in marriage "the parents of the girl always demand for their child a price;" and "forced marriages often produce the most tragic results. . . . A union prompted solely by love would be a monstrous infraction of the duty of filial obedience, and a predilection on the part of a female as heinous a crime as infidelity. . . . Their maxim is, that, as the emperor should have the care of a father for his people, a father should have the power of a sovereign over his family." Meanwhile it is observable that this legally-unlimited paternal power descending from militant times, and persisting along with the militant type of social structure, has come to be qualified in practice by sentiments which the industrial type fosters: infanticide, reprobated by proclamation, is excused only on the plea of poverty, joined with the need for rearing a male child; and public opinion puts checks on the actions of those who purchase children. With that militant type of social structure which, during early wars,

became highly developed among the Japanese, similarly goes great filial subjection. Mitford, qualifying previous statements, admits that needy people "sell their children to be waitresses, singers, or prostitutes;" and Sir Rutherford Alcock says that "parents, too, have undoubtedly in some cases, if not in all, the power to sell their children." It may be added that the subordination of young to old, irrespective of sex, is greater than the subordination of females to males; for abject as is the slavery of wife to husband, yet, after his death, the widow's power "over the son restores the balance and redresses the wrong, by placing woman, as the mother, far above man, as the son, whatever his age or rank." And the like holds among the Chinese.

How among the primitive Semites the father exercised capital jurisdiction, and how along with this there went a lower *status* of girls than of boys, needs no proof. But, as further indicating the parental and filial relation, I may name the fact that children were considered so much the property of the father, that they were seized for his debts (2 Kings iv. 1; Job xxiv. 9); also the fact that selling of daughters was authorized (Exodus xxi. 7); also the fact that injunctions respecting the treatment of children referred exclusively to paternal benefit: as instance the reasons given in Ecclesiasticus, chapter xxx., for chastisement of sons; and the further fact that in Deuteronomy, xxi. 18, stoning to death is the appointed punishment of a rebellious son. Though some qualification of paternal absolutism arose during the later settled stages of the Hebrews, yet along with persistence of the militant type of government there continued extreme filial subordination.

Already in the chapter on the Family, when treating of the Romans as illustrating both the social and domestic organization possessed by the conquering Aryans during their spread into Europe, something has been implied respecting the *status* of children among them. In the words of Mommsen, relatively to the father, "all in the household were destitute of legal rights—the wife and child no less than the bullock or the slave." He might expose his children: the religious prohibition which forbade it "so far as concerned all the sons—deformed births excepted—and at least the first daughter," was without civil sanction. He "had the right and duty of exercising over them judicial powers, and of punishing them as he deemed fit, in life and limb." He might also sell his child. It remains to say that the same implied development of industrialness which we saw went along with improvement in the position of women during the growth of the Roman Empire, went along with improvement in the position of children. I may add that in Greece there were allied manifestations of paternal absolutism: a man could bequeath his daughter, as he could also his wife.

If, again, we compare the early states of existing European peo-

ples, characterized by chronic militancy, with their later states, characterized by a militancy that had become less constant and diffused, while industrialism had grown, differences of like significance meet us.

We have the statement of Cæsar concerning the Celts of Gaul, that fathers "do not permit their children to approach them openly until they have grown to manhood." In the Merovingian period a father could sell his child, as could also a widowed mother—a power which continued down to the ninth century or later. Under the decayed feudal state which preceded the French Revolution domestic subordination, especially among the aristocracy, was still such that Chateaubriand says, "My mother, my sister, and myself, transformed into statues by my father's presence, only recover ourselves after he leaves the room;" and Taine, quoting Beaumarchais and Bretonne, indicates that this rigidity of paternal authority was general. Then, after the Revolution, De Ségur writes, "Among our good forefathers a man of thirty was more in subjection to the head of the family than a child of eighteen is now."

Our own history furnishes kindred evidence. Describing the manners of the fifteenth century, Wright says: "Young ladies, even of great families, were brought up not only strictly, but even tyrannically. . . . The parental authority was indeed carried to an almost extravagant extent." Down to the seventeenth century, "children stood or knelt in trembling silence in the presence of their fathers and mothers, and might not sit without permission." The literature of even the last century, alike by the deferential use of "sir" and "madam" in addressing parents, by the authority parents assumed in arranging marriages for their children, and by the extent to which sons, and still more daughters, recognized the duty of accepting the spouses chosen, shows us a persistence of filial subordination proportionate to the political subordination. And then, since the beginning of this century, along with the immense development of industrialism and the correlative progress toward a freer type of social organization, there has gone a marked increase of juvenile freedom; as shown by a greatly moderated parental dictation, by a mitigation of punishments, and by that decreased formality of domestic intercourse which has accompanied the changing of fathers from masters into friends.

Differences having like meanings are traceable between the more militant and the less militant European societies as now existing. Along with the relatively-developed industrial type of political organization in England, there goes a less coercive treatment of children than in France and Germany, where industrialism has modified the political organizations less. Joined with great fondness for, and much indulgence of, the young, there is in France a closer supervision of them, and the restraints on their actions are both stronger and more numerous: girls at home are never from under maternal control, and

boys at school are subject to military discipline. Add to which that parental oversight of marriageable children still goes so far that little opportunity is afforded for choice by the young people themselves. In Germany, again, there is a stringency of rule in education allied to the political stringency of rule. As writes a German lady long resident in England, and experienced as a teacher: "English children are not tyrannized over—they are *guided* by their parents. The spirit of independence and personal rights is fostered. I can therefore understand the teacher who said he would rather teach twenty German [children] than one English child—I understand him, but I do not sympathize with him. The German child is nearly a slave compared to the English child; it is, therefore, more easily subdued by the one in authority."

Lastly come the facts that in the United States, long characterized by great development of the industrial organization little qualified by the militant, parental government has become extremely lax, and girls and boys are nearly on a par in their positions: the independence reached being such that young ladies often form their own circles of acquaintance and carry on their intimacies without let or hinderance from their fathers and mothers.

As was to be anticipated, we thus find a series of changes in the *status* of children parallel to the series of changes in the *status* of women.

In archaic societies, without law and having customs extending over but some parts of life, there are no limits to the powers of parents; and the passions, daily exercised in conflict with brutes or men, are restrained in the relations to offspring only by the philoprogenitive instinct.

Early the needs for a companion in arms, for an avenger, and presently for a performer of sacrifices, add to the fatherly feeling other motives, personal and social, tending to give something like a *status* to male children; but leaving female children still in the same position as are the young of brutes.

These relations of father to son and daughter, arising in advanced groups of the archaic type, and becoming more settled where pastoral life originates the patriarchal group, continue to characterize societies that remain predominantly militant, whether evolved from the patriarchal group or otherwise: victory and defeat, which express the outcome of militant activity, having for their correlatives despotism and slavery in military organization, in political organization, and in domestic organization.

The *status* of children, in common with that of women, rises in proportion as the compulsory coöperation characterizing militant activities becomes qualified by the voluntary coöperation characterizing industrial activities. We see this on comparing the most militant un-

civilized peoples with others that are less militant; we see it on comparing the early militant states of existing nations with their later more industrial states; we see it on comparing nations that are now relatively militant with those that are now relatively industrial. And we are especially shown it by the fact that in primitive uncultured societies which are exceptionally peaceful the *status* of children is exceptionally high.

Most conclusively, however, is this connection shown on grouping the facts antithetically thus: On the one hand, savage tribes in general, chronically militant, have, in common with the predominantly militant great nations of antiquity, the trait that a father has life and death power over his children. On the other hand, the few uncivilized tribes which are peaceful and industrial have, in common with the most advanced civilized nations, the trait that children's lives are sacred, and that large measures of freedom are accorded to both boys and girls.

IMAGINATION.[1]

By Dr. ELLIOTT COUES, U. S. A.

LADIES AND GENTLEMEN: Amid the asperities of the great political crisis which has convulsed a nation, it is pleasant to find the elegant repose of a *salon* where culture and refinement stand like sleepless sentinels on guard against dissension; and in the Lenten season—when the fugitive madrigal of society is hushed in the measured cadence of the penitential psalm, and the brilliant poppies of fashion grow pale in the shadow of the palm—it is meet that thought should turn from outward things to the contemplation of those within.

The few moments during which an unworthy member of the Society is indulged to-night will be devoted to the consideration of Imagination as one of the intellectual faculties which, if common in some degree to all, is nevertheless, in its highest development, the rarest, most precious, and most splendid, of human endowments. I need not—I shall not—be coldly critical now, nor seek to bend your judgment to my will; for I must speak my aspirations, not my personal experiences, and move you from the heart, or not at all. The subject bids defiance to the trammels of custom or precedent, and will be bound by no conventionality.

For *facts*, as simply such, I dare say I have a great and growing contempt, perhaps less due to any familiarity I may have acquired, than to my habitual contemplation of structures without reference to

[1] Read before the Literary Society of Washington, D. C., March 17, 1877.

the materials of which they are composed. The architect, not his workmen—the plan, not the details of its execution—the design, not the methods of its accomplishment—these are within the higher view to which intellectual insight may aspire. Let us pay tribute to the gifted poet who taught us to contrast the insignificance of a fact with the sublime signification of a truth. No one may imagine for a moment that the imaginative faculty is an imaginary thing, or doubt the reality of imagination, because it is immaterial and immeasurable, inscrutable to the physical senses, unsusceptible of analysis or synthesis, triable by no test, overriding logic, outwitting philosophy, laughing at science—this imperious mistress of mind, this fertile mother of all art!

This, that, and the other, of things unnumbered, material and immaterial, wise and otherwise, make up the marvelous microcosm we call Self—the world where, like the sun of the planetary system, shines the intellect with perfect splendor. But, as the spectrum has dissected the solar ray, so has the understanding, by a process of self-inflicted vivisection that seems scarcely less than divine in its insight, pierced and resolved the mysteries of its own composition. We know that the mind is a bundle of many fagots, the united strength of which can never be broken, though racked on doubt and put to the wheel of despair—though cast beneath the car of superstition, or consigned to the nether millstone of inhuman persecution. We know that these mental fagots are of many kinds—sturdy oak of the scientist, pliable ash of the schoolman, sail-bearing pine of the positivist, cypress of pessimist, rose-wood of optimist, heart-wood, it may be, for all of us; and the one mysterious piece, so like and yet so unlike them all. Let the rest season, nay, even blacken: this one is changeless and ever-enduring, as fresh and as green as if cut but to-day from the parent stem; it buds on forever, like a wonderful air-plant whose tendrils find nourishment wherever there is sensitized atmosphere, and needs the grosser nurture of no vulgar mould; this veritable Hamamelis, witch-hazel of the mental sheaf, fitly styled the "divining-rod;" for this is the magic wand of the sculptor, the painter, the poet, the singer, the seer alike!

Technical definition of the imagination may be found in the dictionaries of all civilized languages—those monuments of learning and labor which compel the most profound respect, while they excite the liveliest emotions of gratitude and sympathy for the men who were born to erect them. But the conventional label of the imaginative faculty need not be recited before this Society; nor need I enlarge upon its manifest inadequacy beyond the requirements of formalism. Definition is, or should be, diagnostic description; but in what terms may that be described which exists only in imagination? Definition implies limitation and boundary; the gist of the term is the setting of corner-stones; but how measure off and survey that which is

boundless? No syllogism is competent here. Let imagination seek its own conclusions, with strong white wings that melt not even in the dazzling light and heat of its own glorious achievements. What care I for the crutch of logic here, or any Ariadne's thread in a labyrinth of verbal niceties! Enthusiasm bears too hard upon the check-rein of sober reflection; fancy leaps lightly; ecstasy beckons, and the lotos is waving over the still, cool waters of my judgment. But expression may lawfully seek even the pinnacle of rhapsody, for naught but superlatives are fitting for that which is beyond comparison.

We can but imagine the possibilities of this attribute of intellect; as its peculiarities deny comparison, and its processes scrutiny, so do its powers defy comprehension. But what of its effective operation and manifest results? What of its purposes and pleasures—of its pangs and penalties? And what, alas! of its perversions? Of these we know something, if not from our own experience, then from the teachings of the consummate masters of expression whose thought-laden voices strike home—or, should they pass over our heads, leave us, at least, in no doubt that something has gone over.

To a practical point first: one excellent and most useful purpose which the imagination subserves at the hands of the gifted few whom the higher development of this faculty makes leaders of thought and watchful guardians of human progress, is, to put men of science on their proper level, and to teach them to know their place.

As this may possibly be considered—by some of my friends whose generous appreciation of my efforts in scientific lines of inquiry may blind them to the slightness of my acquirements—to be rather a ticklish position for me to assume, let me fortify with authority as well recognized in literature as is that of the sinewy, daring, and brilliant gladiator of the scientific arena who stigmatized poetry as "sensuous caterwauling." [1] It has been perceived and said, in sub-

[1] Although, in the sphere of imagination, "facts" are apt to be regarded as troublesome and impertinent, and looseness of statement as only a very venial transgression, yet, for the benefit of those readers who care for accuracy, it may be stated that the author of this celebrated phrase, that has given so much offense to artistic and poetic minds, did not use it in the manner here stated. Prof. Huxley has never, as we are aware, "stigmatized poetry as sensuous caterwauling." It was not poetry itself, but only *some* poetry, to which he applied this eminently felicitous epithet; and if Wordsworth were living, he would no doubt cordially indorse it. We give the memorable passage, as it will bear frequent repeating.—(Ed.)

"In these times the educational tree seems to have its roots in the air, its leaves and flowers in the ground; and I confess I should very much like to turn it upside down, so that its roots might be solidly imbedded among the facts of Nature, and draw thence a sound nutriment for the foliage and fruit of literature and of art. No educational system can have a claim to permanence unless it recognizes the truth that education has two great ends to which everything else must be subordinated. The one of these is, to increase knowledge; the other is, to develop the love of right and the hatred of wrong.

"With wisdom and uprightness a nation can make its way worthily, and Beauty will follow in the footsteps of the two, even if she be not specially invited; while there is, perhaps, no sight in

stance, that the great scientists and the great artists are in really closer brotherhood than many suppose—they hold divided sway over much common ground; it is only a seeming paradox, that few discoveries in science, perhaps no great ones, have been made without the exercise of the imagination, or of some faculty so nearly like it that distinction between them is difficult; for the line which separates the operations and results of imagination from those of induction is obscure. Ratiocination is the twin-brother of imagination. The apple that Eve plucked, and the apple that Newton saw fall, grew on the same tree.

But to my intrenchment: "Poetry," says one who understood it, "is the first and last of all knowledge—it is immortal as the heart of man. If the labors of the men of science should ever create any material revolution, direct or indirect, in our condition, and in the impressions which we habitually receive, the poet will sleep then no more than at present; he will be at the side of the man of science, carrying sensation into the midst of the objects of science itself. The remotest discoveries of the chemist, the botanist, the mineralogist, will be as proper objects of the poet's art as any upon which it can be employed, if the time should ever come when these things shall be familiar to us, and the relations under which they are contemplated by the followers of the respective sciences shall be manifestly and palpably material to us as enjoying and suffering beings. If the time should ever come when what is now called science, thus familiarized to men, shall be ready to put on, as it were, a form of flesh and blood, then the poet will lend his divine spirit to aid the transfiguration, and will welcome the being thus produced as a dear and genuine inmate of the household of men." [1]

This utterance of half a century ago seems like prophecy now when the presaged changes are imminent. The conflict may nevertheless be protracted as long as either contestant is blinded to the real strength of his antagonist—senseless though it be to attempt the impossible divorce of the material from the immaterial, of matter from force, of the body from the spirit—that would be death. And it is the physicist himself who is loudest to proclaim that, without the force which gives motion to material particles, there is no light, no heat, no life.

the whole world more saddening and more revolting than is offered by men sunk in ignorance of everything but what other men have written—seemingly devoid of moral belief or guidance, but with the sense of beauty so keen, and the power of expression so cultivated, that their sensuous caterwauling may be almost mistaken for the music of the spheres.

"At present, education is almost entirely devoted to the cultivation of the power of expression and of the sense of literary beauty. The matter of having anything to say beyond a hash of other people's opinions, or of possessing any criterion of beauty, so that we may distinguish between the godlike and the devilish, is left aside as of no moment. I think I do not err in saying that, if science were made the foundation of education, instead of being, at most, stuck on as a cornice to the edifice, this state of things could not exist."

[1] Quoted from E. C. Stedman's "Victorian Poets," the page where Wordsworth is thus reproduced being further laid under contribution.

Here I would repeat with emphasis, what I intimated in the beginning, that the microscopic eye which peers too long and too intently upon the motes of facts which play in the sunbeam, will be blinded to the force and beauty of the truths which both the motes and the beam conspire to announce.

In thus insisting upon the intimate relationships which I believe subsist between the offices of the imaginative and those of the reasoning faculty, I must not be misunderstood to depreciate or disparage the mighty prowess of the latter, which I love to contemplate. Pure reason, as expressed—I had nearly said symbolized—in the simple, faultless syllogism, has nothing to fear from the sovereignty of the imagination. It is beautiful and fearful to see that clear, cold, naked blade, gleaming with steel-blue temper, resistlessly incisive—to see it cleave with equal ease the solid ingot of ignorance and the gossamer web of illusion—to see it work like a giant steam-hammer, smoothly, noiselessly, and irresistibly, whether its power be adjusted to the cracking of an egg-shell of superfine subtilties, or the forging of the massive links by which it is anchored secure in a storm of error. Yet this Titan is not omnipotent; its powers are limited; and it is precisely at the point where reason hesitates that the office of imagination begins. The higher faculty takes up the story when reason omits to point the moral, and adorns the tale that Nature tells to man. It brings her seeming discords into one grand harmony, and crowns the noble shaft of Science with the immortal wreath of Art.

I speak of imagination in its full development, and in the truest, highest, and best sense that the term can bear; and I am reminded here to draw a broad, even if a devious and uncertain, line of distinction between this splendid faculty and mere Fancy—a pert Miss, whose wills-o'-the-wisp are too often mistaken for the head-light of the imagination. I will not weary you with over-nice formalities of definition in a case where shades of difference blend. Know, by their fruits, that fancy is a parody on imagination. The play of fancy is quips and quirks and airy nothings, and the whole mob of littlenesses we call smart and clever. The working of imagination breathes life into marble and canvas, inspires the drama, the poem, the symphony, and vivifies systems of religion.

What faculty but the imaginative can conceive, what but the power of the imagination itself can convey, the full meaning of this soul of genius? It is creative; and, when this is said, expression falters by the wayside of anticlimax. If there be within us one single spark of the divine fire, this spark it is that sends "the long light shaking" from pillar to pillar of the temple that the lesser god of the imagination rears to a God eternal, till it irradiates the shrine where all men sooner or later must kneel in devotion; and we, who now gaze wistfully at the veil which screens the inner sanctuary from eyes

profane, may yet be permitted to kiss the hem of a seamless garment. Oh, the searching, the far-reaching insight of the epigram, "If there be no God, man must invent one!" Invention, conception, imagination, creation, are synonymous, and in one sense convertible terms.[1]

The pleasures of the imagination—if so slight an expression may hint at a meaning, the fullness of which is rapture or transport—are manifold, and too manifest to require subtilty of discrimination for their recognition and explanation. These are among the things of blessed memory, of blissful hope, and among those the reality and universality of which are confirmed by all experience. Even those who cuddle the bantlings of their fancy, in the fond delusion that they nurture the offspring of the fertile mother, feel somewhat of the charm indescribable. What, then, the serenity, what the majestic repose, of the creators of thought after their labor, we may only faintly imagine.

What of the pangs and penalties now—what of the price to be paid for this power? To bring forth in travail was not the sentence of one-half the human race alone. There have been those, indeed, like Raphael, who have wrought the miracles of imagination in the sunshine of the heart, to sweet music of the soul; but oh, so few escape the throes of thought-birth! Physiologists tell us of a certain mental process they call "unconscious cerebration." The operation of the imagination unconscious of labor is better known by another name—inspiration; its expression is revelation; its mouth-piece the seer. But rare clay, and only the finest, incases such spirits; men must work in the storm, in sorrow and suffering, each to his measure of creative ability. Let us never forget, in the terrible struggle for expression, that it is given to lips which press the sword of pain to speak to fellow-men the words "Go thou up higher!"

I crave your indulgence for one other thought. Authority and responsibility go hand-in-hand with equal pace. The measure of creative ability is the measure of accountability for its exercise, and the measure of the penalty which perversion of the godlike faculty entails. Like every other energy in Nature, the imagination is equally potent for good and for evil. Let the bravest man tell me he never shudders when he looks within, at the possibilities there disclosed. There is power to make this earth seem nearer heaven or hell. Whose rebellious imagination conceived it were better to reign below than to serve above? Sound is as full of discord as of harmony. Light may blind us, or guide us on our way. Heat constructs and heat destroys. The dual nature of every force wars with its opposite. The imagination is equally potent to sanctify and to pollute. Guard, then, this gift with fear and trembling; great issues depend upon this most powerful, most perilous, and most precious endowment of the intellect. Not like the victor in history need we sigh for other

[1] "In seinen Göttern malet sich der Mensch."—Goethe.

worlds to conquer, if we move the world of the imagination to the ends of truth and beauty; for a greater triumph is ours then, and the soul may leap at the inward shout, "Victory! victory! conquest of self!"

A PHILOSOPHICAL EMPEROR.[1]

By CALVERT VAUX.

AT our last meeting we listened with keen interest to all Mr. Lewis had to say about the Emperor Justinian; and his dramatic presentation of the subject cannot fail to leave a permanent impression on our minds, in regard to the life of this conspicuous example of a bad type of Roman. Selfish and sensuous, remorseless, bloodthirsty, energetic, full of vitality, a barbarian at heart; repulsive in his theories, odious in his practices, true to the woman he chose with an accurate instinct as his mate—not as wife or mother, or with any respect for the sex to which she belonged, but rather as an exaggerated exception to every idea that was then, and is now, current in regard to what a woman ought to be. There was nothing attractive or genial in the life of either Justinian or Theodora; and, so far as this forcible sketch allowed us to form an opinion, we were unable to discover any suggestion in the so-called civilization of the period that would be likely to help us in these times.

Imperial Rome, at the beginning of the Christian era, may of course be viewed from a different standpoint; and it seems to me worth while to-night to follow the clew that is given us by the writings of another Roman emperor, Marcus Antoninus, who began his reign in the middle of the second century.

We do not depend here on any exaggerated history, or on a narrative full of misstatements, of the biased and interested kind, that appertain to the work of a contemporary reporter; but we have the clean words of the man himself, "published, and not published," as Aristotle said of his own writings to Alexander, who expressed a distaste to having such exquisitely subtile brain-work scattered broadcast in the common highway, where it might be picked up by anybody. The volume seems to be a commonplace book, made up of notes that have no special connection with each other in the pages on which they happen to stand, but are very definitely related in the sequence of moods that occur to the writer. It would, indeed, be interesting to collate the scattered beads of similar color, and group them together.

[1] "Marcus Aurelius Antoninus," a paper read before the New York "Fraternity Club."

When the Japanese embassadors visited the United States, it was remarked that the manners of the most refined men among them were essentially European or American, if we choose so to state it; not that they were in the smallest particular borrowed or assumed, but because there is a logic in the culture of the human being, that brings about the same results all the world over, so far as manners are concerned. The style of Marcus Antoninus has this cosmopolitan air. He seems to have been the really complete ideal of a cultivated man; and his ways of thinking, his methods of expression, his social views, his manners, in fact, are correspondingly broad.

He would be at home in any century; but in none so completely, it seems to me, as in the nineteenth. You long to hear of his introduction to Darwin and Spencer, and feel that the conversation would grow interesting at once. The deeply-rooted doctrine of special creation is, we know, now losing force day by day, for all who have the opportunity to become acquainted with the current results of scientific investigation, even in a superficial, popular way. The invention of a matured animal is seen to be inconceivable, because all the facts that appertain to the idea of maturity are so definitely associated with the recognition of advancing age, that the conceptions are found to be inseparable. One of the scientific puzzles has therefore been to account in an intelligent manner for the different phases of life that occur from age to age; to suggest, as it were, some positive vehicle whose duty it has been to carry along the sequence of influences from generation to generation. Draper makes a suggestion in this direction, and points out that *the air we breathe* is the grand receptacle from which all living things come, and to which they all return. It is, he says, the cradle of vegetable, the coffin of animal life: made up of atoms that have once lived, and that have run through innumerable cycles of change, its particles await their turn for further reorganization. A corresponding thought also appears to have passed through the mind of Antoninus; not, of course, precisely in the same form, but there is an intelligible hint of the idea in the following sentence: "If souls continue to exist, how does the air contain them from eternity?"

Every era has what may be called its fashionable real problem for discussion. Sometimes it is ethical; at others, mechanical; or it may be artistic.

The recognition of a process of development in all things—or, as it is well termed, "evolution"—is the essential natural law which seems just now to be the important centre of scientific interest; and it may almost be said to be an outgrowth of the present decade. Yet in our author we see the same kind of yeast fermenting, and becoming an incisive statement in appropriate words. "Observe constantly that all things take place by change. Accustom yourself to consider that the nature of the universe loves nothing so much as to change

the things which are, and to make new things like them. . . . For everything that exists is, in a manner, the seed of that which will be, and to think only of seeds that are cast into the earth, or into a womb, is a very vulgar notion. . . . In the series of things, those which follow are always aptly fitted to those which have gone before; and the things which come into existence exhibit no mere succession, but a certain wonderful relationship. . . . You exist as a part; you will disappear in that which produced you; or, rather, you will be received back into its seminal principle by transmutation. And, by consequence of such a change, I too exist, and those who begat me, and so on forever in the direction of the past; for nothing hinders us from saying so, even if the universe is administered according to definite periods of revolution."

Although habitually thoughtful and theoretical, his main desire is to be equal to the work of the day, whatever it may be. He expects to meet with opposition, as a matter of course, and tries to be always light-armed, cheerful, and ready for a run to the nearest summit, from which a new view may be obtained.

His experience shows the immense advantage of good fortune, when crystallized in the form of a liberal, far-reaching education; and one feels that to produce a man so cool, complete, and many-sided, none of his advantages were less than he required. The instinct that suggests the possession of wealth as a desideratum to nine-tenths of the race, finds here a sufficient defense. We want to have leisure, opportunity, plenty of right to occupy other people's time, and plenty of time to exercise our rights. In Antoninus we find a man, an emperor, who has been liberally brought up from the first; who confesses to having always had everything good under the sun; who complains of nothing in his personal experience; and who is as far as possible from repeating the words of his Oriental predecessor, "Vanity of vanities, all is vanity." Nothing of the kind appears in his notes. He is a shrewd, busy, responsible man of the world; always giving orders and attending to the details of his position. He is, of course, never free from the influence of flatterers, hypocrites, and time-servers. He is exposed to selfish, baneful influences, as every emperor must be, but he is equal to the emergency; his self-respect encourages him constantly to draw the line between his own and other people's experiences, and to keep his own unconfused. He is temperate and simple in his personal habits from taste and from principle.

When the Russian Emperor Nicholas, who was a military chief in the fullest sense, visited England, he took his iron camp-bedstead into every palace that was placed at his service. The Duke of Wellington had the same habit to his dying day, his bedroom being a bare and almost unfurnished apartment. Antoninus had this soldier's custom, but "he loved temperance for its elegance, not for its austerity." It is possible, he says, for a man to live in a palace without

wanting either guards or embroidered dresses, or torches and statues, and such-like show. It is, in fact, in such a man's power to bring himself *very nearly* to the fashion of a private person, without being for this reason either meaner in thought or more remiss in action with respect to the things which must be done for the public interest in a manner that befits a ruler. He doubtless received a forcible influence in this direction from his uncle, the emperor who preceded him, in regard to whom he says: "The things which conduce in any way to the commodity of life, and of which fortune gives an abundant supply, he used without annoyance, so that when he had them he enjoyed them without affectation, and, when he had them not, he did not want them."

He appears to have been himself at an early age a hard student, to have adopted a plain, coarse dress, and to have lived a laborious, abstemious life. He was of a winning nature, and had a great affection for his teachers, who were numerous, and all eminent in their several professions. His uncle and adoptive father, Antoninus Pius, a truly noble man, gave by his example the key-note to many points in the character and taste of Marcus. He studied law carefully to fit himself for the high place he was destined to fill, and of course learned the Roman discipline of arms. He abandoned the studies of poetry and rhetoric advisedly; not from any lack of appreciation, but partly because he was made aware that his gift did not lie in that direction, and partly because he found these studies too fascinating for a young man with the responsibilities before him that he expected to assume.

Although he began his reign a century and a half after the birth of Jesus, it is evident that he is unaware of any influence that has been brought to bear on his own mind that may be traced to this source. "A soul," he says, "should be ready at any moment to be separated from the body, to be extinguished, or to continue to exist; but this readiness should come from a man's own judgment, not from mere obstinacy, as with the Christians."

There is, according to Leslie, sufficient evidence that he did not prevent, as he might have done by direct edict, a persecution of Attalus and other Gallic Christians in the year 177. In his time the opposition between the old and the new belief was continually growing stronger, and the adherents of the heathen religion urged those in authority to a more regular resistance to the invasions of the Christian faith. It must of course be remembered that the Christians themselves maintained that all heathen religions were false, and openly opposed the heathen rites; thus making a declaration of hostility against the Roman Government, which tolerated all the various forms of superstitious worship that existed in the empire, and that could not consistently leave unrebuked an intolerant religion, which declared that all the rest were false. The rules against the Christians were

made in the time of his predecessor, Trajan; and his own powers were, doubtless, limited by constitutional forms.

Among his acknowledgments to his teachers and friends, he mentions that he learned from his governor to be neither of the green nor the blue party at the games in the circus (showing that the feud was in active force at the time); also endurance of labor, to want little, to work with his own hands, not to meddle with other people's affairs, and not to be ready to listen to slander. "From Rusticus," he says, "I learned not to be led away to sophistic emulation, nor to be writing on speculative matters, nor to deliver little hortatory orations, nor to be showing myself off as a man who practises much discipline." From the same teacher he also learned not to walk about the house in his out-door dress, and, as he says, "to write my letters with simplicity, like the letter Rusticus himself wrote from Sinuessa to my mother."

He appears to have been a Stoic, and thanks one of his tutors for introducing him to Epictetus; but he had none of the harshness, indifference, or self-assertion, that has become associated with the idea of Stoicism—perhaps a little unjustly, although there is always some ground for a good, wholesome prejudice against such a representative word.

For his wife, Faustina, he expresses great admiration. Neither she, however, nor her mother, who had the same name, succeeded in preserving a character unspotted from attack by the historians; and if his wife deserves the criticisms that are extant (of second-rate authority, however, Leslie says), even the Theodora that Prof. Lewis has given us so vivid an account of was hardly more vicious in taste, or reckless in practice. Swinburne has chosen her name as the key-note for a *tour de force*, and makes it the lay-figure on which to drape forty verses, in each of which the second line rhymes with Faustine. She seems in the poem to be closely related to Poe's Leonore, who was eliminated (the author tells us) out of his personal consciousness in accordance with the logical rules of imaginative and rhythmic art.

> "You have the face that suits a woman for her soul's screen,
> The sort of beauty that's called human in hell, Faustine.
> You could do all things but be good or chaste of mien,
> And that you would not if you could. We know Faustine."

His individual view of domestic life must, however, count for much, even in opposition to Swinburne. He says: "I thank the gods that, though it was my mother's fate to die young, she spent the last years of her life with me; that I have such a wife, so obedient, so affectionate, and so simple; and that I had abundance of good nurture for my children."

It is, perhaps, fair enough for the teacher to say that faith is best

shown by works; but the interesting aspect of any faith is best shown by the theory involved, the intellectual ideal, the point aimed at, the sweep of the curve; and we are at no loss for information of this kind with regard to Antoninus, although there is but little record of his personal practice. His faith, as a man of the world, was in a good, social habit of life; in active, industrious, kindly coöperation. He believed in the present opportunity, in its duties especially. Enjoy life (he says) by joining one good thing to another, so as not to leave even the smallest interval between; and make your acts refer to nothing else than to a social end—not forgetting that the kinship is close between every man and the whole human race, which is not a community of a little blood or seed, but of intelligence.

Although an emperor, he was, therefore, in a certain sense, a very good republican; and he argues that we ought to propose to ourselves an object in life that shall be of a socially political kind, and actually stigmatizes any thought that tends to destroy social union as one of four principal aberrations of the superior faculty. He has an appreciative sense of humor that would easily become grim, if the whole soul of the man were not basked in sunshine, and full of good-tempered acquiescence in the mysterious chances (as they seem to be) of Providence. Heraclitus, he says (after so many speculations on the conflagrations of the universe), was filled with water internally, and died smeared over with mud.

He then gives several other equally untoward illustrations, and proceeds quite cheerfully to draw his moral and urge a constant readiness to close the voyage of life.

The defect in his range of ideas is in the direction that might be anticipated—in the too great detachment and isolation of the purely mental capacity. We do not find a comprehension of the close and intimate connection between material and immaterial (amounting to identity so far as personal experience is concerned), which has been established by modern scientific research. An undue prominence is given to the power of individual will in the direction of self-control and the avoidance of evil; sufficient allowance is not made for human nature—that is, the exaggerations of passion, appetite, or, in general terms, of temperament. There is, however, no suggestion of prejudice, no shallow closing of the avenues through which fresh information may come, and one feels that when with our modern opportunities for investigation it does come, the fresh statement is in harmony with what has preceded it in the definitions of Antoninus, which prove to be right as far as they go, but are incomplete.

Although a logician on principle, by natural gifts, and by constant practice, there is nothing pitiless in his logic. It would almost seem that he had been aware of the hardness that so easily accompanies the power to state with precision a sequence of cause and effect, and he chooses rather to show how easy it is to prove logically that

a charitable view may be taken of the evil doings of others. He says, for example: "When a man has presented the appearance of having done wrong, say, how can I be certain that this is a wrongful act? And even if he has done wrong, how do I know that he has not condemned himself?"

His definition of the way in which injuries should be met shows the true Christian spirit. He urges as invincible the continuance of a benevolent disposition toward even the most violent, and recommends that you "quietly admonish him and calmly correct his errors at the very time when he is trying to do you harm; saying, 'Not so, my child, we are constituted by Nature for something else;' and show him his error, with gentle tact, not with any double meaning or in the way of reproach, but affectionately and without any rancor in your soul, not as if you were lecturing him, nor yet that any by-stander may admire, but either when he is alone, or with caution as if he were alone."

His style is not particularly elegant, certainly not poetic or imaginative, but it has an intensely masculine quality, and its virile power of grasp is sufficient to insure to the thoughts of Marcus Antoninus a long future.

When an ethical principle is to be inculcated about which (we will assume) there is no difference of opinion, the appeal will be made to one kind of intelligence by thinkers of the calibre of (let us say) George Herbert, and to another kind by studious inquirers of a type which may be represented by Emerson and Antoninus, about whom all that one can say in the way of definition is that his appeal in each separate instance seems to be directly made without qualification or limitation, to himself, to you, to me, to every being capable of understanding the meaning of ordinary words. It is never special, but always general and in the direction of character which belongs, like the air, to every human being, and not in the direction of genius or acquirement, which is owned like the earth by human beings very unequally. Take, for instance, the following quotations: "You say, men cannot admire the sharpness of your wit. Be it so. But there are many other things of which you can hardly say you are not formed for them by Nature. Show those qualities then which are altogether in your power, sincerity, gravity, endurance of labor, contentment with your portion, benevolence, frankness, freedom from trifling, magnanimity. Do you not see how many qualities you are immediately able to exhibit in which there is no excuse for natural incapacity and unfitness?"

The most potent charm of the Christian doctrine is in this direction. It is adapted to the rich and poor, but chiefly to the poor; to the educated and uneducated, but very decidedly to the uneducated. Probably the philosophy of Antoninus, emanating, as it does, from a rich, unhampered experience, bears the marks of the habitual sur-

roundings, and is more polished and metaphysical than it would have been if its author had been born in a hut; but it is nevertheless always practical, and while clearly recognizing that there are inevitable limitations of human power, it makes a grand claim for the possible capacity of human intelligence; it is not a system of in-door ethics that fails of efficiency when taken into the open air and exposed to the weather. Take, for example, what he says of religion: "To those who ask, 'Where have you seen the gods? how do you comprehend that they exist? why do you worship them?' I reply, in the first place, that they *may* be seen even with the eyes. In the second place, I have not seen my own soul, yet I honor it; and in respect to the gods, from what I constantly experience of their power, I comprehend that they exist, and I venerate them."

Of immortality he says: "It hardly seems possible that men who through pious acts have been most intimate with the Divinity, when they die should be completely extinguished. But if this is so, rest assured that it ought not to have been otherwise; for, you see, in this inquiry you are disputing with the Deity, who would not have allowed anything in the order of the universe to be neglected unjustly and irrationally. . . .

"Wait for death with a cheerful mind, as being nothing else than a dissolution of the elements of which every human being is compounded. But if there is no harm to the elements themselves in each continually changing into another, why should a man have any apprehension about the change and dissolution of all the elements; for it is according to Nature, and nothing is evil that is according to Nature." It may, of course, be claimed that he is an altogether exceptional man, and that his lofty views were unshared by his contemporaries. This, however, is not a sufficient explanation.

In a note to one of Moore's songs we are told that it was founded on this anecdote in Warren's "History of Ireland:" "The people were inspired with such a spirit of honor, virtue, and religion, by the great example of Brien, and by his excellent administration, that as a proof of it we are informed that a young lady of great beauty, adorned with jewels and a costly dress, undertook a journey alone from one end of the kingdom to the other, with a wand only in her hand, on the top of which was a ring of great value; and such an impression had the laws and government of this monarch made on the minds of all the people that no attempt was made upon her honor, nor was she robbed of her clothes and jewels." Whether this history is true or not, there is no gainsaying the fact that it existed in the popular Irish thought, or it would never have found expression. It requires a delicate and chaste imagination to conceive of such a legend, and the character of the people to-day seems to justify us in admitting its essential probability.

These writings of Antoninus may be accepted in a similar sense as

proof positive in regard to the good type of an imperial Roman. The ideas could not have grown in an isolated way on uncongenial soil; there must have been other good, imperial Romans, and many of them. He is a noble exemplar of his own age, and we learn through him to respect his contemporaries. He is also interesting as a representative man in a more extended sense. He combines the cool, unbiased, intrepid spirit of modern scientific inquiry with the earnest veneration of the moralist, and the speculative curiosity and audacity of the metaphysician. To-day we find the scholars and poets a little out of sympathy with the scientific men, and the men of science declaring war against such doctors of orthodoxy as persist in standing aloof on (what they think) intrenched ground.

Antoninus seems to be habitually clear from prejudice or superstition. When he makes a statement it is evident that he is giving us his views as fully and freely as possible, without let or hinderance, and this absence of partisanship constitutes the special charm that seems destined to give a fresh perennial interest to his monograph. The subjects he touches on are of universal value to all human beings when in a thoughtful mood, and it seems very doubtful whether his pure and forcible statements will ever lose their power, because they have been from the outset so thoroughly refined from all dross in the literary method of their presentation that it is hardly possible to conceive of any advance in culture that will leave them behind the age in this respect.

BAD ODORS IN RESERVOIRED DRINKING-WATER.[1]

FROM PROFESSOR S. A. LATTIMORE'S REPORT.

THE citizens of Rochester were much inclined to congratulate themselves—and certainly on excellent grounds—when they had brought water thirty miles from the crystal depths of Hemlock Lake for the use of the city. But last year, to the astonishment and disgust of the people, their water became so offensive as to give rise to grave apprehensions respecting its effect on public health. In October it suddenly began to emit a peculiar fish-like odor, which continued until the following December. It was a very natural suggestion that this odor must be due to the presence of fish, which had somehow found their way from the lake into the main pipes, and thence into the smaller service-pipes, where their progress had been arrested, and they were undergoing slow decomposition. It is well known to those familiar with the experience of other large cities, that

[1] Abstract of a Report to the Executive Board of the City of Rochester, N. Y., on the Recent Peculiar Condition of the Hemlock Lake Water-Supply. By S. A. Lattimore, Ph. D., LL. D., Professor of Chemistry in the University of Rochester.

similar annoyances are by no means uncommon elsewhere. Regarding this we learn that "not long after the introduction of the Croton water into New York, and of the Cochituate water into Boston, the fish-like odor prevailed for some time to a most disagreeable extent. While this odor is of most frequent occurrence, others of very different character are occasionally reported. Last year the Bradlee Basin, which supplies a part of the water for Boston, became affected with an odor described as closely resembling cucumbers. None of the other ponds in the neighborhood were similarly affected. About the same time the water of Springfield, Mass., exhaled the odor of green corn. In 1874 the water of Cherbourg, France, became intolerable from an odor undistinguishable from that of a pig-sty. This same odor occurred last summer in Horn Pond, from which East Boston and Charlestown are in part supplied. The odor of decaying wood is not uncommon, especially in early summer." And, in response to a circular letter sent to the various cities of the United States and Canada, the author learned that the fish-like odor was far more prevalent than he had previously supposed, it having occurred in all the following cities: Concord, N. H.; Keene, N. H.; Burlington, Vt.; Boston, Mass.; Lowell, Mass.; Holyoke, Mass.; Brookline, Mass.; Springfield, Mass.; New Haven, Conn.; West Meriden, Conn.; New Britain, Conn.; Hartford, Conn.; Auburn, N. Y.; Newburg, N. Y.; Poughkeepsie, N. Y.; Trenton, N. J.; York, Pa.; Baltimore, Md.; Norfolk, Va.; Nashville, Tenn.; and St. Paul, Minn.

In these letters reference is made to the cucumber-odor, as having been observed at Boston, Springfield, Holyoke, Mass., and at Poughkeepsie, N. Y. In the majority of cases the odor was connected with the increase of temperature in the beginning of summer, and continued only for a week or two. In other cases it began in the autumn, and continued into the winter or early spring. The supply of the cities named is derived from ponds, lakes, and rivers; but it is interesting to note that there is no report of any fish-like odor in the water of any city supplied from the Great Lakes. These odors are extremely volatile; boiling readily expels them, and they gradually escape when the water is exposed to the air.

Hemlock Lake, in Livingston County, New York, situated thirty miles south of the city of Rochester, is about seven miles in length, and has an elevation of about 400 feet above the level of the city. The water is taken from the northern end of the lake, and conveyed in a large conduit-pipe a distance of nearly twenty miles to the main storage-reservoir in the town of West Rush; from here it is carried to the reservoir at Mount Hope, whence it is distributed to all parts of the city. "The difference of elevation between the storage and the distributing reservoirs is 115 feet, and renders it possible, except in winter, to throw up the whole volume of water, as it enters the Mount Hope Reservoir, to a height of about eighty feet, thus

producing a magnificent fountain, which is visible from all elevated points throughout the city. By this means the whole body of water is thoroughly aërated before it enters the distributing mains."

The investigation, which consisted of chemical analysis and microscopical examination, began December 14th. Samples of water were taken from Hemlock Lake, from the chief storage-reservoir, and from the city mains. The analysis, which was conducted with great care, indicated remarkable purity of the water. It should, however, be noted that earlier experiments might have shown a different result. The microscopical investigation was also conducted with scrupulous care, and with such precautions as to preclude the possibility of the escape of any important organism. The total quantity of foreign matter obtained was in each case surprisingly small—"a thousand gallons of water yielding not more than one or two grains of residue, a large proportion of which consisted of minute particles of clay and sand." The facts obtained regarding the fish-like odor were of curious interest. The samples of water taken from the lake and from the reservoirs were found to be entirely free from unpleasant odor, while the fish-like peculiarity was plainly perceptible in the water drawn from the main just before it entered the Mount Hope Reservoir. The odor increased in intensity the farther the water flowed through these mains; so that, in the northern portions of the city, it was very offensive. It is noteworthy that all the water which reached the city had passed through not less than four wire screens with meshes a quarter of an inch in diameter, and in no case had a service-pipe been known to be obstructed by any portion of the body of a fish. "In filtering many thousands of gallons of water, at different times, and under such conditions as to arrest multitudes of the minutest organisms, not the smallest fragment of a bone, or fin, or scale, of a fish—parts which would longest resist decomposition, and float away in the water—has ever been detected."

In answer to the question, "What cause, then, can be assigned for this most peculiar odor?" Prof. Lattimore asserts that it must be due to the decomposition of some form of fresh-water algæ. He draws his conclusions partly from the investigations of others, and partly from his own observation and experiment. After the disappearance of the odor from the water, he observed that microscopic algæ, which had collected on the filters through which water had been flowing for twenty-four hours, exhaled an odor strikingly like that given off by a blade of early spring grass, when crushed by the fingers. A minute quantity of these algæ put into distilled water, and kept covered for a few hours, revealed an odor which was distinctly recognized as that which had recently affected the water from the lake.

This experiment, with others pointing in the same direction, leads to the conclusion that the fish-like odor must be due to some obscure condition of the algæ—most likely to their decay and decomposition.

Concerning the possibility of communicating so powerful an odor to a vast quantity of water by means of an almost infinitesimal amount of algæ, the author says: "That this odorous material was extremely volatile, was obvious. It soon vanished from water left at repose in the open air. Heat expelled it still more rapidly. It was for this reason that no trace of it could be perceived in the open reservoirs where it could escape as rapidly as it was generated, while in the closed conduit from the West Rush Reservoir to the Mount Hope Reservoir, and in the street mains of the city, it was prevented from escaping except when a faucet was opened. Again, in its extreme volatility we have the clearest explanation of the fact that so minute a quantity of odorous material could infect so large a quantity of water. A single flower will instantly communicate its perfume to every particle of the air in a large room. A grain of musk, or a shred of scorched animal tissue, will taint a vast volume of air with no loss of substance appreciable to the most delicate balance."

Regarding the public health, there is no evidence furnished that warrants even a suspicion of any deleterious effect, and this is strictly in accordance with what would be expected if the above explanation is correct.

To the question, "Can any measures be taken to prevent a recurrence of this trouble?" the following answer is made: "It is useless to attempt a reply until we come to understand the causes and conditions precedent to such results. This knowledge can evidently be acquired only by long and patient observation, if obtained at all; and, if obtained at last, it might be only like our knowledge of the laws of meteorology, which indeed enables us to predict the coming changes of the weather with great certainty, but which confers on us no power whatever to control it. On the other hand, it is at least conceivable that, if we understood the life-history of these offensive algæ, and the conditions favorable or unfavorable to their growth and multiplication, we might possibly be able to prevent or favor their growth, or to hasten or retard their destruction in such manner as to prevent the recurrence of the trouble."

A RUN THROUGH THE MUSEUMS OF EUROPE.

By THOMAS M. BREWER.

IN 1875–'76 the writer, having a general interest in the science of ornithology, and making a special study of that somewhat neglected branch which relates to the peculiarities of birds' nests and eggs, devoted, at intervals, more than a year to visiting some of the principal museums of the Continent of Europe, and afterward of

England. Naturally, in these somewhat hasty observations, his favorite departments received the larger proportion of his attention.

It was his fortune to first place his foot on the Old-World soil in the quiet and lovely, the very quaint and very old-fashioned, little city of Bremen, and there to make the acquaintance of two ornithologists whose reputation is world-wide, and who, among the followers of this science, stand in the front ranks—Dr. Georg Hartlaub and Dr. Otto Finsch.

Dr. Hartlaub is a physician, in full practice, standing at the head of his profession, but finding ample time, without neglecting his professional duties, to devote to the study of his favorite science, and to favor the world with valuable contributions, the results of his careful and exhaustive researches. A little past the prime of life, he is still in full and vigorous health. He has made the birds of Africa his principal study. As incidentally attesting Dr. Hartlaub's popularity and high standing among his brother ornithologists, it may be here mentioned that in Gray's "Hand-List of Birds" are no less than twenty-six different species, and one genus, upon which has been bestowed the name of Hartlaub—a compliment that has been paid to no other naturalist, living or dead, not even to the great Linnæus or to the illustrious Cuvier.

Dr. Finsch, though a much younger man, is fully the peer of his distinguished townsman in his reputation in ornithological science. He is the Director-in-Chief of the Natural History Museum of Bremen, which, though by no means among the largest, enjoys the reputation of being one of the most excellent in its arrangement, in Europe. In regard to this, unfortunately, I had not complete opportunity to judge. A new building was in the course of erection on the site of the old museum, and most of the collections, being packed away, were inaccessible. A portion of the birds were open to inspection, and well attested the taxidermic excellence of their preparation, which is said to characterize not only this department, but the whole museum. Dr. Finsch is author of an excellent and, to the student, invaluable monograph on the parrots; and, although he has largely contributed, with Dr. Hartlaub, to investigate the ornithology of Africa, probably there is no one living more generally familiar than he with the ornithological forms of the world. Since I met him he has been absent from home, in charge of an important exploring expedition to the arctic islands, north of Eastern Asia, from which he has recently returned.

Passing from Bremen to Düsseldorf, on the Rhine, our way took us through the old capital of Westphalia, that quaintest of quaint places, Münster; one, too, made so painfully memorable in history by the Vandal acts of the fanatical Anabaptists, and the even more terrible retribution that was visited upon their leaders. There we made a pause, in order to examine a very remarkable private collection of

nests and eggs. It was in the dwelling of one of the prosperous fur-merchants of that city, a gentleman of culture, who, without making any pretensions to scientific attainments, had got together one of the largest and richest local collections in oölogy on the Continent of Europe. It contained between seven and eight thousand specimens, well prepared, carefully arranged, and wonderfully rich in suites and varying sets, of the eggs of European (chiefly Prussian) birds. While I afterward saw other private collections that may contain the eggs of more species, I saw none that so fully presented, in series of sets, the eggs of the birds of any one locality. It was an interesting peculiarity that this collection had been commenced by its owner's grandfather, and three generations had made its increase the amusement and study of their leisure moments. Pains had been taken to note the date of each separate acquisition, and such a collection is thus rendered peculiarly interesting to the student of the local ornithology, on account of the light it cannot fail to throw upon the relative abundance and distribution of the birds of the region. Unfortunately for the student of science, such collections as this are rare and exceptional.

In Berne, the capital of Switzerland, is the National Museum of that republic. This contains an immense mass of materials, illustrative of various departments, some of them in good preservation, but others quite the reverse. A commendable effort had been begun to exhibit all the species of the animal kingdom found in Switzerland, but the space allotted is insufficient; the show-cases are ill arranged, and betray an evident want of funds sufficient to keep up to the highest standard what might have been made one of the finest collections of its kind in the world. One contributor had given to the museum what must have been in its day a very fine collection of the nests and eggs of the birds of Switzerland, including several eggs of that now nearly extinct bird, the lammergeyer of the Alps. Long exposure to the light and dust had rendered the whole valueless.

The geological and mineralogical collections have fared better, and are really very fine. The pure crystals of black quartz are of immense size, and those of clouded topaz are truly magnificent. One cannot doubt the correctness of their claim to be the finest in the world. Crowded into the small apartments of an irregular building, though well worth a noble hall, devoted exclusively to their exhibition and preservation, are some of the most interesting historical collections anywhere to be met with. Besides the relics of the ancient Lake-dwellers, which seem almost to unite the two departments of ethnology and geology, may be seen the remarkable trophies captured by the Swiss in their memorable war with the Burgundians, under Duke Charles the Bold, four centuries ago last summer (in 1476), including a rich altar-piece, and the tapestries and other costly trappings of his regal tent, which are among the most interesting relics to

be found. The wealth of these collections is in painful contrast with the poverty of their surroundings.

Though a little out of the order of our visit, we will now turn to Geneva, where, in the Natural History Museum, we find everything in agreeable contrast with the shortcomings of the National Museum at Berne. The spacious and elegant building is comparatively new, is well arranged for light and the exhibition of specimens, and is pleasantly situated in the midst of a large, open park. Here may be studied the famous conchological collections that once belonged to the Duke of Massena, and which, to the student of this department of science, afford added interest as having been the types for Lamarck's great work. Here, too, is an immensely rich and very interesting collection of fossils, systematically arranged by the distinguished Pictet, and, among them, all the geological types of De Saussure. There is also an immense collection of coleopterous insects. The ornithological collection of this museum is not large, but exceptionally good. The specimens are all excellent, are well mounted, and present several commendable features, rare in Continental collections. The exact locality where each specimen was obtained is carefully recorded, and the local group of the birds of Switzerland forms an interesting and instructive feature. Another not common feature is an excellent, systematically-arranged collection of the eggs of birds. Though, comparatively speaking, not a large one, it is quite respectable even in point of numbers; and, in the care given to its preservation and in its arrangement, it is a model, and almost unique. This department is under the charge of M. Alois Humbert, an excellent ornithologist, whose explorations in Asia have contributed many specimens of great rarity, one of the most interesting being a veritable nest of one of the tailor-birds, so long the subject of unverified description.

In Stuttgart, the capital of Würtemberg, is a very large and valuable Museum of Natural History, that fills twenty spacious rooms in the Building of the Archives. To geologists, and to students of zoölogy and comparative anatomy, its collections in these departments are replete with interest. The collection of birds is very rich in rare African types, but, in the absence of Prof. Krauss, the director, these could not be inspected to advantage. The museum has no collection of eggs, but there is in the little kingdom of Würtemberg probably the largest oölogical collection in the world; the richest in its number of species, and excelling in the rarity and beauty of specimens, and in the extent and fullness of series, exhibiting variations in eggs of the same species. It belongs to Baron von Warthausen, and is preserved in his castle near Biberach. Unfortunately, I cannot speak of it from my own observation, as I had gone far beyond it before my invitation to visit and examine it overtook me in Dresden. It is, however, well known to be of great and constantly-increasing value, containing one-

sixth of all the known species. It is especially rich in African and South American kinds, collected, at great expense, by expeditions sent out by the baron at his sole charge.

In Dresden, world-renowned for its galleries of art, and for museums illustrative of kindred departments, one would naturally look for a correspondingly rich Natural History Museum. Still, small and disappointing as the Dresden Museum of Natural History is, it contains the typical collections in oölogy of the late Dr. Thienemann, and therefore cannot be passed by in total silence. This museum has been recently placed under the charge of Dr. Adolf B. Meyer, a distinguished ornithological explorer in New Zealand, and his accession has already been followed by reconstructions full of promise. The Thienemann oölogical collection is an immense one, has been gathered from all parts of the world, and contains all the types of his illustrated work on oölogy. Unfortunately, in the latter part of his life he suffered his vast collection to lapse into great disorder. He ceased to continue a systematic arrangement; successive additions were but partially unpacked, and the identifications of many forever lost, or rendered doubtful. After Dr. Thienemann's death his family presented his collection, in this chaotic condition, to the Royal Museum, and time has but added to the confusion. Labels have been misplaced, and the best of experts cannot always restore them with certainty. Nevertheless there are still materials for creating by far the largest and richest public oölogical collection in Europe. It abounds in very rare and choice kinds; among others, no less than seven eggs of the ivory gull—an egg so rare that only two others are known to be in any museums, one in Dublin and one in Copenhagen.

The extensive museum of Berlin, owing to the inclemency of the weather and the rooms not being heated, could only be partially and hastily examined. The general plan of arrangement was simple and good, and the specimens appeared to be in excellent condition. It possesses a small but valuable and well-arranged collection of eggs, in which the great point of interest is a series of nests and eggs from Siberia, collected by a man of science exiled to that desolate region; many of these are very rare and unknown to other collections. The mineralogical collection is one of the most extensive on the Continent, and is especially rich in meteorolites. Its great interest centres in the collections brought by Humboldt from Central and South America. Dr. William Peters, a distinguished naturalist, is at the head of this museum, and the ornithology is under the charge of the venerable John Cabanis, who ranks high in his department, and is well known as the editor of the *Journal of Ornithology*.

The Imperial Cabinet of Natural History of Vienna deserves fuller mention than our space permits. Its vast collections would require almost a lifetime to examine exhaustively, and no single volume could do justice to all their various points of interest. Indeed, a

good-sized and condensed volume has been devoted to its collections of birds only and from Brazil alone; and when it is remembered that this collection possesses specimens of 1,200 species exclusively from that region, besides all the collections of the Novara Expedition, and that these are but a portion of the immense whole, some idea may be formed of its magnitude. The museum is also rich in its collections of nests and eggs. Many of these are uniques, and were procured by the Novara and other exploring expeditions. These will remain for the present unarranged, awaiting their transfer to new quarters in an immense building which the Government is now constructing, and which in size and position promises to be one capable of doing ample jusice to this noble collection. In charge of the ornithology is Dr. A. von Pelzeln, a naturalist of high repute, and a most courteous and obliging gentleman. At the time of our visit, the fishes and reptiles were in charge of Curator Dr. Franz Steindachner, a pupil of Prof. Agassiz, and for a while his assistant in the Museum of Comparative Zoölogy at Cambridge. He has more recently been promoted to the post of director-in-chief, a position for which he is most admirably qualified.

The natural history museums of Southern Italy, from Naples to Florence, are almost exclusively devoted to human and comparative anatomy. In the lovely City of Flowers we find, in her Royal Museum of Physical and Natural Science, an institution under the royal patronage, and unique in its character. It is a university for teaching natural history and the physical sciences. Here in the home of Galileo, and where his memory is deservedly held in high honor, astronomy receives its full share of attention. Dr. Parlatore, an excellent botanist and an eloquent lecturer, instructs in botany; and the director of the museum is Dr. Henry H. Giglioli, well known to scientific men as the naturalist of the Magenta Exploring Expedition. This institution is fortunate in having at its head so accomplished a gentleman and so enthusiastic a naturalist, and under his judicious efforts to advance its interests it bids fair to become in all its departments well worthy of the Tuscan capital. Its anatomical collections are already deserving of the highest commendation.

In the little city of Pisa, so attractive to strangers for its architectural peculiarities, is a museum well worthy of attention. To the student of ornithology it is interesting as the home of Suvi, the pioneer ornithologist of Italy. Here is a local collection of birds made by him of exemplary merit. The specimens are arranged in family groups, in small, air-tight glass cases, in each of which is presented a single species in all its varied forms, as modified by age, sex, or season. This includes the nest and eggs, the young chick, the summer and the winter plumage, and all the variations of the sexes—at once a novel, instructive, and interesting feature.

In Genoa the Civic Museum, under the patronage and general di-

rection of the Marchese Giacomo Doria, is a model institution, in view of the general excellence of the plan on which it is conducted. Placed on a high position, commanding a magnificent view over a most lovely landscape, surrounded by beautiful grounds, it is a jewel well worthy of such exquisite setting. The building is large and convenient, the collection one of recent date and well arranged. Its most noteworthy feature is that nearly or quite all the specimens have been obtained by Italian explorers, and all have been precisely determined as to their original locality. The museum possesses very many special rarities, in some instances the only known perfect specimens in existence, as a new and undescribed specimen of a cassowary from the Arroo Islands. Its publications are eminently first class, creditable alike to the liberality of the patrons and the scientific merits of the members of this institution. The director of this museum is a young nobleman of scientific tastes and acquirements, using an ample fortune with liberality and good judgment. He is a direct lineal descendant of the historic Doge of Genoa, a first-cousin to the late Prince Pamphili Doria, of Rome, and a near kinsman of another great benefactor of Genoa, the Duke of Galliera, who signalized the last year of a useful life by the gift of 30,000,000 francs to improve the harbor of Genoa.

Milan is rich in museums and collections of various kinds, both public and private. Its Museo Civico, largely devoted to collections of natural history, and under the direction of Dr. Cornalia, is especially rich in its collection of reptiles, claimed to be the finest in Europe—in that of paleontology, and in its collection of skulls. Its director is a gentleman of high scientific attainment, and has largely contributed to the growth and development of the institution over which he has presided so many years. But to an ornithologist the great attraction of Milan is the unequaled private collection of Count Hercules Turati. His cabinet of mounted birds is the finest, as it is also one of the largest, in the world, and, though there may be several public collections both in America and in Europe that outnumber his in species, there is probably not one that approaches it in the uniform excellence, beauty, and perfection of plumage. There are superb specimens of every known species of the birds-of-paradise, very rare and very costly, and all in exquisite plumage. No expense is spared in procuring additions to this collection. Liberality, courtesy, and devotion to science, confirm this gentleman of rank as one of Nature's true noblemen, and unite with him to render his collection a great attraction to the ornithologists of all Europe.

The Museum of Natural History of Turin was commenced under the patronage of the royal house of Savoy, and is still aided by the Italian Government. But just at present Italy is called upon to expend so much upon her armies and her navies, her railroads and her public schools, that she has but little money to devote even to the favorite museum of her king. Nevertheless, this museum contains much

that is worthy of consideration. The construction of the national railroads of Piedmont enriched its paleontological department with many unique and wonderful relics of the dark ages of geology; and, above all, in its director, Count Tommaso Salvadori, the Museum of Turin possesses one who is conceded to be, *par excellence*, the ornithologist of Italy, and who enjoys a world-wide reputation as among the first in this department of science. The collection of birds is, of course, well arranged and especially interesting in types. At the time of our visit, Salvadori's private room was literally strewed with many hundred specimens of birds-of-paradise, representing all but two or three species of this family, with series by the hundred of several species. These had been recently collected by two Italian travelers, one set belonging to the Italian Government, the other to the Civic Museum of Genoa, and referred to Salvadori for examination, and to aid him in his monograph of this family.

The Garden of Plants, in Paris, is an institution too generally familiar to require more than a passing mention. The new houses for the protection of the living animals are models in their contrivance, more especially the one for the reptiles and batrachians. The Ornithological Museum, though not of itself very extensive, is particularly interesting to scientific students as the depository of collections made by the several national exploring expeditions of France. Among these are many unique and typical specimens, not known to exist elsewhere in museums. The collection of eggs is also wonderfully interesting, is very large and well preserved, and contains not only many very rare kinds, but is especially noteworthy as possessing a large number of species not to be found in any other public collection, some of them laid by birds in confinement.

Leyden, in Holland, could not be passed by without at least a brief visit to the venerable Dr. Schlegel, and the far-famed museum under his charge. The time was, and that not immemorial, when this museum contained the largest collection of birds in the world. Even now it is surpassed by very few, and is still superior to all others in its representations of East Indian species. Its strongest point is its collection of monkeys, to which class of animals Dr. Schlegel has given great attention, and of this our ancestral family—according to Darwin—it possesses the surprising number of 1,500 different species. Dr. Schlegel, though of mature years, is still in vigorous health, a most charming old man, bright, cheerful, and affable, possessing an inexhaustible fund of conversation and knowledge, enriched by the careful observation of a long and well-spent life. His museum possesses a very rich collection of the eggs of the birds of Java and other East Indian possessions of the Dutch.

Of the British Museum, as a whole, it would be impossible to speak from competent knowledge, except with much more time than we could give to so endless a task. The writer will say that all he did or

could see was very disappointing. Its collection of mounted birds, though containing much that was typical, rare, and interesting, was in the individual defects of a large proportion of its specimens in painful contrast to the private one of the Milanese banker. The collections of eggs were not arranged, and had not been procured with any special care. They seemed to have been all accumulated by chance donations, and required an immediate and very careful revision. It is, however, but justice to say that, since the zoölogical portion of the museum has been under the charge of Mr. Sharpe, a systematic rearrangement has been begun, and, so far as it has proceeded, is a great improvement. When the natural history portion of the museum is removed to Kensington, and rearranged in the new building in the course of construction, it is to be hoped that the managers of this institution will avail themselves of their great opportunities, now so strangely neglected, and render this branch of the British Museum better worthy of being the one national museum of a great empire. The contrast between the Museum of London and that of Newcastle-upon-Tyne, or that of Liverpool, cannot but be painful to the national pride of a true English naturalist.

For popular attractions, for general excellence of arrangement, and expedients for the instruction and education of the people in natural history, the Derby Museum, or, as it is now called, the Free Public Museum of Liverpool, far surpasses anything of its kind. It was founded by an ancestor of the present Lord Derby, and is under the admirable direction of Mr. Thomas J. Moore; but it would extend this paper too far to point out the excellence of its various devices for popular instruction. Here you can see the external form of bird or animal, and next to it its own skeleton, so that the bony frame and the outward appearance may be studied at the same moment. In one compartment are a full-grown lion and lioness, and with them young lions of various ages, from the tender nursling to the nearly full-grown whelp. In another compartment is well represented water in which appear disporting various forms of swimming-birds, old and young, demonstrating to the observer their position, when swimming, both above and below the surface. The collections are large and varied, and so arranged as to attract and educate the visitors.

In conclusion, only brief mention can be made of a few of the private collections of natural history in which England abounds. In his private apartments in Hanover Square, London, Prof. Osbert Salvin, of Cambridge University, stores his rich collections of birds, and eggs, and insects, gathered by himself in Central America. They are especially abounding in specimens from Guatemala, are admirably arranged, and well worthy of careful study. Howard Saunders, Esq., who makes the families of gulls and terns his especial study, possesses collections that are indescribably interesting. They consist of the birds (with their eggs) of Europe, together with exotic representatives of the two fam-

lies in which he is chiefly interested. He has been an active explorer in Spain, and the collections made there by himself are the chief attractions of his cabinet. Henry E. Dresser, Esq., a London merchant, and author of a magnificent work on the birds of Europe, now in course of publication, possesses, at his residence on South Norwood Hill, the most complete collection of the eggs of the birds of Europe probably in existence. It is admirably arranged, containing many fine suites of the least common kinds, and very many species not in any other collection.

The collections in oölogy, made by the late Mr. John Wolley, the indefatigable explorer of the ornithology of the arctic regions of Europe, were bequeathed to Prof. Alfred Newton, of Cambridge, who has illustrated them in a publication of great elegance. This collection is of great scientific as well as pecuniary value. Its series of specimens of some of the rarest arctic eggs are immense. The market money-value of one of these series—that of the waxwing—at its lowest computation, is not less than £100.

Within the close of the venerable Cathedral of Durham, the writer was privileged to examine, in the cabinet of Rev. Canon Tristram, the largest collection of eggs it was his good fortune to see in Europe. This gentleman is an excellent ornithologist, has been a great traveler and explorer in America, North Africa, Palestine, Syria, and elsewhere, and his collections, which number over 1,700 species, have been largely taken by his own hand.

And here our space compels us to close our narrative, leaving much that was to us exceedingly attractive unsaid and undescribed. Though disappointing in certain instances, our study of European collections, as a whole, incomplete as it too often was, and all too hurried as to the time allotted, was ever full of instruction, interest, and enjoyment.

THE SEWING-MACHINE IN POLITICAL ECONOMY.

IT is very probable that as we obtain a fuller and more accurate command of facts relating to the production of wealth under perfectly free conditions in countries like our own, where intelligence is widely diffused, it will be found that the methods of most efficient production are those which necessarily contain within themselves the methods of most effectual distribution. It has been customary to assume, or infer, that the laws regulating the production of wealth were one thing, and the laws regulating its distribution were another; so much so, indeed, that while legislation could not interfere with production without doing harm, it might and ought, on grounds of justice and duty, to regulate distribution. There is strong reason to believe

that interference is just as undesirable and pernicious in the latter case as in the former. Given the most efficient production, that is to say, articles produced in the cheapest, swiftest, and most skillful manner by the free competition of invention, capital, intelligence, and industry, and it is true, as a necessary condition of production so sustained, that the wealth created by and arising from it is distributed step by step, as the process goes on, in the most equitable manner among all the parties engaged in the enterprise.

This is a proposition to be tested by facts, carefully put together, not by ingenious argumentation on hypothetical cases; and it fortunately happens that a paper of great ability on "The Sewing-Machine and its Results," contributed by Mr. John Plummer (well known as a high authority on industrial topics) to the "Companion to the Almanac" for the present year (1877), furnishes the precise sort of evidence required.

The sewing-machine first appeared as a practical invention about thirty years ago. Thimonnier, the real originator of the idea, was a Frenchman, and, like too many great inventors, he did not live to enjoy any part of the fruits of his genius. Elias Howe, who followed Thimonnier, was an American working artisan, and found his first real support in England about 1847. At the present time, that is, about thirty years after the establishment of the invention, there are upward of 4,000,000 sewing-machines in use in various parts of the world; and the annual number of new machines produced in this country is estimated at 80,000, employing about 100,000 persons. In France, Germany, and Belgium, the production of machines is very large, and in the United States the annual out-turn of machines is perhaps greater than in the whole of Europe. In 1862 it was estimated that in the United States each machine saved to its owner 50*s.* a week, or say £130 per annum, in wages alone; or an aggregate saving in wages, for the whole country, of about £30,000,000. In 1875, that aggregate saving had risen to £100,000,000.

The facts, therefore, to be considered are imposing by their magnitude, and of high value, by reason of the diversity of the countries and populations by which they are supplied.

Mr. Plummer says: "In England the sewing-machine was first employed in the manufacture of common stays and corsets, of which several million pairs are annually produced. In earlier days the materials were sewed together by needlewomen of the poorest class, principally the wives of seamen and dock-laborers, whose earnings seldom averaged more than 3*s.* or 4*s.* a week. . . . From the stay-trade the sewing-machine found its way into the trades connected with the production of shirts, mantles, dresses, trousers, coats, and other articles of male and female clothing. In some of these trades the needlewomen could not, even by working very long hours, obtain more than 3*s.* or 4*s.* a week, and the public were continually shocked by painful rev-

elations of destitution and misery among seamstresses. Hood's 'Song of the Shirt' expressed the public feeling. Needlewomen's Aid Associations were started, but wholly failed to lessen the evil. . . . *The appearance of the sewing-machine changed all this.* Shirts were made more rapidly and more cheaply than before, but the workwomen were better paid and did not work so many hours. The hours of labor fell, indeed, from eighteen hours a day to eleven or twelve."

The demand for hand-labor increased, because, while the machine did the heavy mechanical part of the work, the cutting out and preparation of the materials rendered necessary more "hands," and a superior aptitude and intelligence. The workers also became to a large extent the owners of the machines worked by them at home; and as the slavery and degradation of the needle became almost abolished, crowds of young women were attached to machine-working by the short hours and the high wages. It is this diversion of female labor which lies at the root of the scarcity of domestic servants, and the extraordinary rise in the wages given to such servants.

Improvements in the machine enabled it to be applied to boots, shoes, harness, and most articles made of leather. In November, 1857, a machine of this kind was introduced at Northampton, and immediately led to organized opposition by the Crispins of that centre of the shoe-trade. This opposition was more or less successful until February, 1859, when the manufacturers of Northampton and Stafford formed themselves into a league, and announced that they were prepared to compel the use of the machines in spite of the opposition of the men. A strike ensued. The men were defeated; and the machines very rapidly revolutionized the whole industry of boot and shoe making. Mr. Plummer says: "With the termination of the strike the operatives became eager to possess machines of their own, and in a short time there were few of the better class of workmen who were not proprietors of one machine or more. These were worked by the female members of their own families, or by women engaged for the purpose." The machines put an end to the more dangerous and unhealthy process of the work. Employers fitted up commodious factories supplied with machines, and hence has arisen the present factory system in the boot and shoe trade, a system as beneficial to the male and female workers as to the capitalists. It is estimated that now at least one-half of the Northampton employers have risen by means of machine-industry from the position of workmen.

Cheapness, rapidity of production, and excellence, led to a vastly increased demand for boots and shoes. Wages were raised; the work was easier; and the buildings in which it was carried on were vastly improved. In Leicester, in 1820, there were 150 operative shoemakers; in 1851 there were 1,375; in 1861, the machine having appeared, there were 2,315; and in 1871 there were 5,703, or nearly four times as many as at the ante-machine date of 1851.

In 1852, says Mr. Plummer, "the average amount of wages obtainable by an experienced female operator was 8*s*. to 10*s*. per week; now the earnings of the female machine-workers are 14*s*. to 16*s*. per week—slower hands get 10*s*., and the best workers 20*s*. to 24*s*. The female 'preparers' of work get 10*s*. . . . The machine has within a few years been applied to the straw hat and bonnet industry of Bedfordshire, and with the best results. Many of the plaiters who now suffer from Chinese competition, will, as machinists, obtain good wages. . . . In the mantle-trade in London, the wages of machinists are high, say, 14*s*. to 20*s*. for middling hands, and 23*s*., 29*s*., and even 33*s*., for superier workwomen."

As the general result, Mr. Plummer says that, "taking all the various industries in which the machine is used, the wages of the machinists may be estimated as being from 50 to 100 per cent. *higher* than the wages received by hand-workers before the machines appeared in the several industries." And he goes on to add: "The changes introduced by the machine have been attended with considerable advantages as regards the physical and social condition of the workers. There is a great improvement in their health and in the comfort of their homes. As regards the shoemaking population, both male and female, the change amounts to an absolute revolution, and decidedly for the better."

The sewing-machine has most effectually stimulated invention in other directions. In all leather manufactures, for example, the old, painful, unhealthy processes are now nearly all done by machinery driven by steam. In the stay and clothing trades the severe labor of using heavy shears by hand is superseded by steam-driven cutters, by the aid of which one man does the work of twenty. The cheapness arising from these appliances has so enlarged the demand that the quantity of labor employed in the trades is far greater than before.

This is the statement of the facts, and there is no reason to dispute it in any essential particular. The outline amounts to this: About twenty-five years ago the articles produced in all the industries connected with the fabrication of sewed, or "made-up," woven, and leather materials, were dear, and, except in the best instances, of inferior quality; and the laborers, male and female, but especially the latter, were among the worst paid, the hardest worked, and the most unhealthy, in the country. A mechanical invention, called the sewing-machine, of moderate cost and simplicity, was then introduced, the objects of which were, by the application of ordinary labor in private houses or factories, to get rid of nearly all the irksome, slow, and unhealthy processes of hand-stitching, and so by reason of swiftness, exactness, and superiority of manufacture, greatly to reduce the selling-price of the articles offered to the public. The effect of this invention was in a few years to establish two radical improvements throughout

the industries in which it was most successful, namely: 1. The lessened price of the commodities to the consumer, their superior quality, and the circumstance that they were articles required by all, but especially by the middle and humbler classes, at once created an enlargement of demand so rapid and strong that it fully kept pace with the more efficient and swifter means of production; 2. The augmented *gross produce* arising from the decided success of the invention in rendering labor more efficient, in saving time, and improving quality, and reducing the outlay and risks of capital, was divided between the employers and work-people wholly by the operation of natural causes. There was no interference of the Legislature on one side or the other; and practically there was no interference of trades-unions to enforce a minimum rate of wages, or to impose restraints on the skill, industry, and deserts, of the individual male and female laborers. Everywhere there were inferior, middling, and superior laborers, earning corresponding wages; and everywhere the skillful and handiest laborers passed naturally into the class of employers and capitalists. It was a free and wholesome coöperation of capital and labor to supply the best and cheapest articles to the cash demand of a vigorous consumption; and the profits arising from the trade were divided between wages and capital wholly in proportion to the special skill and industry of the individual employers and employed; with the result, as we have seen, of raising wages from 50 to 100 per cent., and adding immeasurably to the comfort, health, and independence of the laborers, but especially of the female portion of them.

But such a result is neither more nor less than *distribution* of the proceeds of production of the most exact and equitable kind. On a large scale the increased quantity of wealth arising from the invention of the sewing-machine has been divided precisely as—on grounds of equity—it is most fit and beneficial that it should be divided; and this equitable and wholesome division has taken place as a *necessary consequence* of the most efficient methods of production being left at perfect liberty, as regards both workmen and masters, to arrive at the cheapest means of commanding and stimulating consumption. If at an early or later stage of the establishment of the sewing-machine it had been possible for the male to exclude the female workers; or, for the two combined to prevent the use of the machine in the houses of male or female workers; or, for any trades-union to enforce a minimum wage, or to impose restraints on individual skill and invention devoted to increase the gross profits—that is to say, the fund alone available for division between labor and capital—it is easy to see that the whole march of the improvement would have been retarded and thwarted. It is clear, also, that the two circumstances which have very materially assisted the success of the machine, as regards both producers and consumers, have been: 1. The small cost of the machine itself, which admitted its effective use in the *homes* of the work-

ers, and in this way has cheapened production by rendering of value the intermittent labor of whole families as it could be spared, and when it could be easiest applied. In this respect the sewing-machine has been the reverse of the former handloom. The machine-workers have prospered because they could take the new invention into their houses without diminishing its force. The handloomers were superseded because the steam-shuttle could not be made a domestic implement. 2. The eminent suitability of female labor to the sewing-machine has secured a class of workers who have had the strongest motives to apply whatever skill and industry they possessed to increase their *piece-work wages* by the extent and efficiency of production. It may be added, indeed, that the great results which have been obtained are among the most cogent illustrations which can be found of the magical influence of payment by results, that is to say, of payment by the piece; for, happily, no other mode of payment has been possible for sewing-machine labor.

The lesson of the whole of this gratifying and hopeful history is, as we said at the outset, that the methods of most efficient production are those which necessarily contain within themselves the methods of most effectual and beneficial distribution: in other words, if we understand and apply thoroughly and truly the conditions which most cheaply, rapidly, and constantly produce wealth, we also, and as a necessary and *pari passu* consequence, understand and apply the conditions which insure the distribution of that wealth among all the parties concerned in the most just and beneficial manner. So far, philosophers and philanthropists have spent their energies in the wrong direction. They have sought for artificial means of what they considered more equal distribution of the products of industry, failing to see that in the circumstances and conditions which render industry on the largest scale most productive there are native and inherent forces which link together production and distribution at every step.—*The Economist.*

CORRESPONDENCE.

HOW A PHILOSOPHIC SKEPTIC WAS RECONCILED TO RELIGIOUS FAITH.

IT has not been usual to regard Herbert Spencer as a reconciler of skeptical minds with religious verities; nevertheless he has labored with great power and earnestness to attain this end, and there has been varied and pointed evidence that this labor has not been thrown away. A letter recently published in the *Chicago Times* states a quite remarkable case of reconversion to Christianity, under the influence of the study of "First Principles." There have probably been many similar cases, though not so conspicuous, and it is not unlikely that there will be a great many more. Perhaps it would be well for our evangelical friends not to overlook this circumstance; and, when they have battered away at hardened old disbelievers in religion with the customary weapons to no purpose, to buy a copy of "First Principles," and, having mastered it, to try Spencer's short method as a last resort. The letter referred to relates to the return of the late Judge Alfred W. Arrington from what is termed "modern infidelity" to the Christian faith, largely through the influence of Mr. Spencer's book. The writer—Mr. C. C. Bonney—was an intimate personal and professional friend of Judge Arrington, and was familiar with the matter of which he writes. Mr. Arrington died in Chicago, December 31, 1867. The communication to the *Times* is as follows.—ED.:

"MR. EDITOR: The *Times* of last Sunday contained a letter written by the late Judge Arrington in 1832, about the time of his renunciation of revealed religion. It is due to his memory that his final return to his early faith be as widely published. In the memoir prefixed to his poems, published after his decease, Mrs. Arrington sketches briefly his religious career, showing him in youth an eloquent preacher, in manhood a truth-seeking skeptic, and at the close of his life a convinced and satisfied Christian. She says:

"'At the early age of eighteen years he commenced to preach, and at that time exhibited an oratoric power that resembled the inspiration of an Italian *improvisatore*. He drew large audiences, and excited the greatest enthusiasm. He continued to preach for several years at intervals, until he lost his childhood's faith; and, after fruitless attempts to find peace in other communions, ultimately abandoned revealed religion. He afterward sought in philosophy a solution of his intellectual difficulties; but, of course, with only partial success. He, however, never abandoned his search for truth. The different systems of metaphysics, from the Indian philosophers down to the latest schools of English positivism, were as familiar to him as the alphabet. The principles of the physical sciences were fully mastered, and their relations to each other and to human life. He sought in every quarter for the knowledge that would enable him to create a sound philosophy of life and morals. . . .

"'The works of Herbert Spencer had a most happy effect upon his mind. He studied them with the greatest delight, and professed to find in them the possible union of science and religion. . . .

"'For some time previous to his last illness, his aggressive skepticism had entirely disappeared, and in various ways he manifested, not only a respect for Christianity, but a strong desire for the gift of faith. This solace was, however, denied him till he lay upon his death-bed, when, to use his own words, "*Like a flash of light, every cloud disappeared, and the vision of Jesus Christ was vouchsafed me.*"'

"I may add to the foregoing extracts that after this event he called his wife to his bedside, and said, among other things: 'Promise me, Leora, that you will assure my friends, especially my professional brethren, some of whom may have been misled by my skepticism, that when I returned to my faith in the Christian religion my mind was not enfeebled by disease, but that my intellect was as clear and strong as ever, and that it was not merely an assent to my early faith, but a conviction as clear as the light of the truth of the supreme miracle of the incarnation. To believe that is to believe all.'

"These are the words as I recall them, and as I believe, if his voice could reach us, he would ask to have them given to the public. His return from infidelity to faith began with his reading of 'The Unknowable,' and particularly the chapter on 'The Reconciliation,' in Herbert Spencer's 'First Principles.'

"I procured and read Mr. Spencer's book at Judge Arrington's urgent request, and learned its effect on his mind in subsequent conversations.

"Some enterprising publisher should give us a new edition of Judge Arrington's writings, with a more ample and detailed sketch of his life than has hitherto appeared. He was a man of extraordinary intellectual

endowments, and the story of his life faithfully told would have all the charm of a noble romance. C. C. Bonney.

"Chicago. *February* 17, 1877."

THE SUN-SPOT PERIODS.

To the Editor of the Popular Science Monthly.

In the course of an inquiry lately made in reference to the periodicity of cold seasons, and their coincidence with the greatest prevalence of the sun-spots, I came to the conclusion (the reverse of that reached by most of those who have written on that subject) that, while there is a recognized periodicity in the sun-spot maxima, and also a seeming periodicity in the recurrence of cold seasons, the cold winters, instead of falling coincident with, oftenest occur intermediate between, the maxima of the sun-spots.

I think the coldest season of the present century was that of 1816, while the sun-spot maximum for that period is placed in 1817. Another remarkably cold winter, and one of which I have a vivid recollection, was that of 1856; while the nearest sun-spot maxima were in 1849 and 1860. Another unusually cold winter occurred in 1866, almost exactly intermediate between the maximum of 1860 and that which followed.

It seems to be taken for granted that the sun emits less heat during the time it is partially covered with spots. But is this a fact which is substantiated by experiment? It is easy to see that its light may be less; but light and heat, though originating and being propagated similarly, are not identical either in their effects or in the mode of propagation. Thin wave-undulations differ very greatly in length and frequency.

If two liquids of different colors and different specific gravity, and which do not readily mix, be poured into the same caldron, the lighter will rise to and cover the surface. If the one of the least specific gravity be the lightest in color, it will reflect light the most readily; and, if the contents of the caldron be agitated, so that the two liquids be made to show at the surface alternately, the reflection will be alternately greater or less, according as each liquid predominates at the surface.

Suppose that, instead of other agitation, heat be applied to the bottom of the caldron. Gradually, with the increase of the heat, upward jets are produced, and the darker liquid breaks through the lighter surface in the act called boiling. These dark fractures of the light surface—do they not correspond to the sun-spots?

In its ordinary state, the body of the sun is enveloped in, and covered by, an exceedingly bright surface, appearing to be slightly reticulated, called the photosphere. When this photosphere is undisturbed, we have the maximum of light. At other times, apparently by increased internal action, the uniformity of this photosphere is destroyed; titanic forces, acting from beneath, rupture it, and produce what to us is the phenomenon of sun-spots.

Now, is it not logical to infer that the increased action which ruptures the photosphere is accompanied by increased heat-radiation? If it be, there is reason for the cold seasons falling not coincident with, but intermediate between, the sun-spot maxima.

Geo. W. Chapman.

A PRETTY BIG DOG-STORY.

To the Editor of the Popular Science Monthly.

The perusal of the interesting article on "Canine Sagacity," which appeared in the December number of The Popular Science Monthly, gave me great pleasure, and caused me to recall to memory a very remarkable case of the same character which came under my own observation about two years ago. I was then practising medicine in Galveston, Texas. One day I was called to see a patient, Mrs. Wechsler, the wife of a German butcher. As I entered the hall of the house where she lived, I was met by a large black dog, who under no consideration would let me pass, until Mr. Wechsler himself came to pacify him and assure him that it was all right. The dog then followed us into the sick-room, and, while I was examining the patient, the dog was watching all my movements most attentively. When I departed, I noticed that I was followed by the dog, who did not leave me until he had seen me enter my office. A few days after this the dog entered my office apparently very uneasy about something. The thought struck me at once that perhaps I might be wanted; so I put on my hat and followed the dog, who immediately started for home, where I found Mrs. Wechsler sick in bed, with no one in the house to attend to her. She was surprised at my timely call, and, when I told her that I had been called by the dog, she related to me what was even more astonishing. She had suddenly been seized by a violent attack of vomiting fifteen or twenty minutes previously, when the dog had picked up an empty tin pan and placed it beside her bed, before *running for the doctor*. This dog, who was only eight months old, had never received any kind of training. It is therefore evident that something like the following train of thoughts must have passed through his mind: Seeing me examine the patient and prescribe for her, he must have conceived the idea that I was the proper person to be there when she was sick. Having made up his mind on this

point, the next thing to be done was to find out where I lived; and this he did by accompanying me to my office. Seeing her vomit, he brought her a tin pan, which he probably had seen her use for that purpose, and then set out for my office. The dog called for me a number of times afterward, but never without my services were needed. He was never told to fetch me, but determined himself when it was necessary to do so. Yours, respectfully,

JOHN SUNDBERG, M. D.

BALTIMORE, *December* 4, 1876.

To the Editor of the Popular Science Monthly.

SIR: In an article headed "Over-Consumption or Over-Production?" in your July issue, Mr. Bunce offers an answer to the question, "Why are the times so hard?" taking as his text Prof. Bonamy Price's article, "One per Cent.," which he pronounces to be illogical, fallacious, and based on unwarranted assumptions. It is not easy to disentangle Mr. Bunce's argument, but the following is believed to be a fair statement of the propositions it involves:

1. That the common ideas in regard to national extravagance are erroneous, it being something essentially different from individual extravagance.

2. That wasteful consumption has had nothing to do with commercial distress; that, on the contrary, destruction produces abundance.

3. That no part of the nation's capital has been lost in unproductive enterprises.

4. That the real cause of the trouble is over-production.

5. That the remedy lies in coöperation among producers to regulate production.

A refutation of these propositions is not the object of this letter; all that time and space will allow is to stand them up, stripped of verbiage, and see how they will look.

In the first place, concerning national extravagance, after pronouncing the idea ordinarily held to be "peculiarly erroneous," Mr. Bunce says: "We think it can be shown that expenditure in the case of the individual, and expenditure in the case of a large number of individuals, have certain essential differences, the difference being that the income of the former is absolutely fixed, while that of the latter is wholly expansive." As it stands, this proposition must mean that wastefulness, a bad thing in the case of the individual, becomes in the case of an aggregate of individuals a good thing; it means that, each man's income being fixed, he cannot safely live beyond it; but, if we add together a "large group" of these incomes, they become "wholly expansive," whatever that may be, and cannot be too recklessly spent; it means, in short, that the whole is something totally different from the sum of its parts.

Mr. Bunce tells us that "*a community is rich because it consumes, abundance being the product and consequent of excessive destruction.*" And here is the proof: "It is evident that the immense consumption of coal has made coal cheap and abundant. It has rendered possible the employment of vast capital in the erection of costly machinery for working, transporting, etc. . . . It is true, the consumption of coal is increased by cheapness, but it is only by extravagance that the machinery by which it is made cheap is put in operation. We have an immense wealth of coal because we consume coal so extensively!" This rule, we are told, works in all, or nearly all, our staples, and the conclusion is, "that in all staple things a nation is rich because it consumes." Was ever the operation of the law of supply and demand so grotesquely construed? That the demand for a commodity stimulates the activity of supply is most true, and, where increase is possible, the supply is increased until the widest area of demand is filled at a minimum cost, but it is only by economy that this minimum can be reached. It is surely only necessary to remember that, no matter what the employment of capital or appliance of machinery, every ton of coal moved a foot represents a given unit of force in the total sum available for supplying human needs, and that, when so used, it cannot be applied to other work, in order to see the full absurdity of the proposition that the nation is the richer if the product be wastefully destroyed instead of being husbanded and prudently used!

The third point made, that no part of the capital of the country has been lost in unproductive enterprises, deserves, perhaps, a little fuller attention because of the peculiar reasoning by which it is sought to be sustained. Mr. Bunce says that these works were largely carried on by what he calls "released energy, by labor not otherwise required," and that so far "the community is not the poorer by a mite in consequence." He is willing to admit that, by the purchase of iron abroad, etc., we have lost a part of our "surplus," but he declares that "the assumption that it impaired our capital is wholly groundless." With such a use of terms, it becomes needful to define what is meant by capital in an economic sense, and to point out the difference between it and the capital stock and surplus of a bank or a life-insurance company. The latter are terms used to designate what a book-keeper knows as the fictitious accounts which show the amount of assets of a corporation; it is a purely artificial division which has been

found convenient in keeping accounts, and has no analogue in the accumulations of a community. The word capital, as used by Prof. Price and economists generally, means the nation's accumulated stock of food, clothing, and the other necessaries of life. So long as these commodities remain unconsumed, they are called free capital; when they are employed to sustain laborers engaged in building a warehouse, a bridge, or a railway, the capital is said to become "fixed," or sunk in such enterprise. If the investment is a paying one, returning the cost with interest, the capital is in time released; if it loses money, ultimately becoming worthless, then the capital is fixed forever, or lost. And the true cost of these works to the community is correctly expressed by the price paid for them, Mr. Bunce to the contrary notwithstanding; for, traced to its ultimate source, the cost of the material used is simply the amount of labor that has been put upon it. Of the vast amount of labor which has been so misapplied, not one stroke can be considered as "released energy—labor not otherwise required." It was labor that was needed elsewhere, as is plainly proved, if proof were needed, by the sharp competition and high wages paid for it. But the assertion that there is no labor that could not be put to better use than to throw it away, needs no proof. "But," he asks, triumphantly, "how is it if the savings of a country have been impaired that capital, at the same moment, should be seeking investment at any rate of interest, that all financial circles are choked with an excess of money?"

"When *I* use a word," said Humpty Dumpty, scornfully, to Alice in Wonderland, "it means just what I choose it to mean, neither more nor less." It is only by attributing a similar mental attitude to Mr. Bunce that the confusion of terms which marks his article is to be explained. Capital has been already defined; money, it may be simply said, is a measure of value, a medium, a commodity, at times a transient representative for capital, when there is capital to represent, but either may exist without the other. The reader will excuse these elementary definitions, as they seem to be called for. Savings, capital, money, it is hardly necessary to say, are not convertible terms; and it requires no profound reasoning to show that idle "money"—undoubtedly the immediate result of lessened trade—may find its ultimate cause in impaired savings. It is because savings have been impaired that economy and retrenchment are enforced; it is because people cannot save, and at the same time go on consuming high-priced commodities with the old recklessness, that prices fall and trade operations become restricted and less profitable; it is because commerce no longer offers high-paying investments, that money accumulates in business centres, and is offered, like other commodities, at low prices. And in view of the fact that it is the *cost* and not the *amount* of production that needs to be lowered in order to renew the activities of trade, this is a most cheering sign.

As has been said, the cause of our trouble, as assigned by Mr. Bunce, is over-production. That is to say, too much labor has been usefully employed, too much machinery has been put in motion, too much cotton has been spun, too much leather made—in short, not to particularize, the wants of the people have been too freely supplied. The economist will, of course, admit, as Mr. Bunce says, that there may be over-production of certain things, but the ill effects resulting from undue production of certain things would be partial and localized, and would tend rapidly to correct themselves. Nothing short of general over-production would account for general depression. And so we are brought face to face with the proposition that there is an unhealthy excess of industrial energy in the world, and that it produces more of the necessaries of life than the workers can profitably assimilate!

A few words as to the proposed remedy. Of course, if it be admitted that over-production is the cause, the cure is obvious: it is to check production, and Mr. Bunce does not hesitate to recommend a coöperation of producers for that purpose. The adjustment of industrial activity cannot be left to natural laws, but combinations must be formed which shall see to it that the forge-fires are not relit, and that the idle operative shall remain idle. With millions of laborers waiting for work, this seems like heroic treatment, but there is no way to limit production but to limit the amount of labor employed. And now we begin to see how "peculiarly erroneous" have been the commonly accepted views. The man who makes two blades of grass grow where one grew before; the inventor who, by machinery, increases and cheapens the aggregate of things made; the industrious and frugal operative, who works long hours and saves his earnings—have hitherto been regarded as useful members of society. But this is all wrong; the "tramp" is your true conservator of public welfare. He takes a share in that destruction which leads to abundance, and he at least cannot be charged with contributing to the evil of over-production.

Regarding the example of France, Prof. Price attributes the successful payment of the indemnity to the fact that France had "saved"—accumulated. It would perhaps have been better to say it was because she

had acquired the habit of living within her means; but neither explanation would suit Mr. Bunce, who says it was solely due to the *manner* in which her savings had been held—they had been kept in old stockings, and, when unearthed, enabled the state to pay the German exactions. The admission that "saving" of any kind produced riches that were available under such an unusual strain is fatal to his position; but, passing this, nothing could be more incorrect than the assumption that the enormous levy was paid out of stocking-hoards. Less than ten per cent. of the sum was paid in coin from any source. The indemnity fund was drawn from three sources: 1. The exchanges of foreign trade (i. e., proceeds of *current production*); 2. By selling foreign bonds and stocks held in France (i. e., by converting the accumulated results of *past production*); 3. By money borrowed from foreign countries (i. e., by discounting the proceeds of *future production*). This done, and realizing that, though the levy was arranged, it was not made good, she has gone on producing with unparalleled vigor.

On the other hand, Germany, upon the strength of her acquired millions, proceeded to make serious drafts on her available industry: 1. By the maintenance of a large standing army; 2. By the employment of vast amounts of labor in constructing fortifications, iron-clads, and munitions of war; 3. By unproductive private enterprises, unduly stimulated by speculation. Of course, productive industry must be restricted; commodities have been made costly in price and poor in quality to such a degree that Prince Bismarck declines to allow Germany to compete in the Paris Exposition of 1878, because of the mortification which would result from a comparison of her products with those of other nations. Here, wages have been paid, and wages have been received; that which Mr. Bunce calls "diffusion" has gone on, and, according to his theory of over-production, Germany should have been spared the commercial evils that have been felt in other countries. The fact is, she is worse off to-day than any nation that has a sound currency, and one of her economic writers suggests with some bitterness that the way out of her troubles is to engage in one more war, as the result of which she should have to *pay* five milliards of francs.

E. R. Leland.

New York, *June* 28, 1877.

EDITOR'S TABLE.

CLARENCE KING ON CATASTROPHISM.

Most of our readers have probably read the brilliant address of Mr. Clarence King on Catastrophism in Geology, recently delivered at the Yale Scientific School, and published in the newspapers. The speaker was fortunate in his topic, which is not only of wide scientific and popular interest, but one to which he has given special study from the American point of view.

When men first began to observe geological phenomena, they were profoundly impressed with the grandeur of their display of power. Rocky masses, miles in thickness, showed that stupendous forces had been at work upon them, upheaving, folding, distorting, and dislocating the mass of strata as if they had been sported with by preternatural powers. Firmly believing that Nature is only about 6,000 years old, all this conjuring with the earth's crust was supposed to have taken place within that time. It was a necessary inference that the forces which had been at work, and the effects produced, were on a scale of magnitude of which people know nothing nowadays. That the world had been drowned in a deluge was deemed certain; and that the whole march of geological transformation had been cataclysmal and convulsive was a natural conclusion. Early geology, therefore, explained things by catastrophes.

But, with the progress of observation and the sobering of the imagination, geologists began to suspect that the notion of catastrophes had been drawn upon a little too freely, and the question arose as to how far causes such as are now in operation can be invoked to explain geological effects. It was recognized as safest to reason from the known to the unknown, and, as the Mosaic barrier gave way, there seemed endless time for the play of geological

changes. It was soon recognized that transformations, such as are now taking place, with indefinite time, might do all that has been hitherto ascribed to catastrophes. A careful study of the varieties and rates of contemporaneous change seemed to establish the conclusion that such action is sufficient to account for all geological results. Those sudden and tremendous demonstrations of which we have no experience were discredited; catastrophes went out of fashion, and uniformitarianism became the dominant idea in geology.

Mr. King holds that this doctrine has been carried too far. Prof. Thompson and his school have tried to corner the geologists on the question of time, maintaining on physical grounds that they must check their periods and duration, which would necessitate the quickening of the activities, and thus induce a return-movement toward catastrophism. Mr. King does not argue the case from this point, but puts it on the ground of direct geological evidence that rates of action and change, of which the world at present knows nothing, have been in play at former times on the American Continent. The following passages are illustrative of his views:

"I have thus hastily mentioned a few of the most important geological crust-changes in America whose rates are demonstrably catastrophic. Besides surface-changes involving subsidence, upheaval, faulting, and corrugation, all of which may be executed on a scale or at a rate productive of destruction of life, catastrophes may be brought about by sudden, great changes of climate, or by intense volcanic energy. In the latter field there are obviously no catastrophes of the first order. Geological maps of the globe have progressed far enough to demonstrate that considerable areas are, and always have been, free from actual ejection of volcanic materials. On the contrary, numerous great regions, notably the western third of our own continent, and the shores of the Pacific, were once literally deluged with volcanic fires. An examination of the ejected rock shows that modern eruptions, by which the volcanic cones of the present period are slowly built up from slight overflows piling one upon another, is not the method of the great Miocene and Pliocene volcanic periods. There were then outbursts hundreds of miles in extent, in which the crust yawned, and enormous volumes of lava rolled out, overwhelming neighboring lands. Volcanoes proper are only isolated chimneys, imposing indeed, but insignificant when compared with the gulfs of molten matter which were thrown up in the great massive eruptions. Between the past and present volcanic phenomena there is not only a difference of degree, but of kind. It is easy to read the mild exhibition of existing volcanoes as a uniformitarian operation, namely, the growth of cones by slight accretions; but such reasoning is positively forbidden in the past.

"If poor, puny little Vesuvius could immortalize itself by burying the towns at its feet, if the feeble energy of a Lisbon earthquake could record itself on the gravestones of thousands of men, then the volcanic period in Western America was truly catastrophic.

"Modern vulcanism is but the faint, flickering survival of what was once a world-wide and immense exhibition of telluric energy—one whose distortions and dislocations of the crust, whose deluges of molten stone, emissions of mineral dust, heated waters, and noxious gases, could not have failed to exert destructive effect on the life of considerable portions of the globe. It cannot be explained away upon any theory of slow, gradual action. The simple field facts are ample proof of the intensity and suddenness of tertiary vulcanism.

"Of climatic catastrophes we have the record of at least one. When the theory of a glacial period came to be generally accepted, and the destructive effects of the invasion of even middle latitudes by polar ice were realized, especially when the devastating effects of the floods which were characteristic of the recession of the ice came to be studied, uniformitarianism, pure and simple, received a fatal blow. I am aware that British students believe themselves justified in taking uniformitarian views of the bowlder till, but they have yet to encounter phenomena of the scale of our quaternary exhibitions.

"A most interesting comparison of the character and rate of stream erosion may be obtained by studying, in the Western Cordilleras, the river-work of three distinct periods. The geologist there finds preserved, and wonderfully well exposed: 1. Pliocene Tertiary river-valleys, with their bowlders,

gravels, and sands, still lying undisturbed in the ancient beds; 2. The system of profound cañons from 2,000 to 5,000 feet deep, which score the flanks of the great mountain-chains, and form such a fascinating object of study, and not less of wonder, because the gorges were altogether carved out since the beginning of the glacial period; 3. The modern rivers, mere echoes of their parent streams of the early quaternary age. As between these three the early quaternary rivers stand out as vastly the most powerful and extensive. The present rivers are utterly incapable, with infinite time, to perform the work of glacial torrents. So, too, the Pliocene streams, although of very great volume, were powerless to wear their way down into solid rocks thousands of feet at the rapid rate of the early quaternary floods. Between these three systems of rivers is all the difference which separates a modern (uniformitarian) stream and a terrible catastrophic engine, the expression of a climate in which struggle for existence must have been something absolutely inconceivable when considered from the water precipitations, floods, torrents, and erosions, of to-day.

"Uniformitarians are fond of saying that give our present rivers time, plenty of time, and they can perform the feats of the past. It is mere nonsense in the case of the cañons of the Cordilleras. They could never have been carved by the pygmy rivers of this climate to the end of infinite time. And, as if the sections and profiles of the cañons were not enough to convince the most skeptical student, there are left hundreds of dry river-beds, within whose broad valleys, flanked by old steep banks, and eloquent with proofs of once-powerful streams, there is not water enough to quench the thirst even of a uniformitarian. Those extinct rivers, dead of drought, in connection with the great cañon system, present perfectly overwhelming evidence that the general deposition of aërial water, the consequent floods and torrents, forming, as they all do, the distinct expression of a sharply-defined cycle of climate, as compared either with the water phenomena of the immediately preceding Pliocene age, or with our own succeeding condition, constitute an age of water-catastrophe whose destructive power we only now begin distantly to suspect."

Having given his reasons for rejecting the idea of uniformity in the course of Nature, especially in Western America, Mr. King proceeds to connect his view with the question of Evolution. It is imputed to him by the newspapers that he arrays Catastrophe against Evolution, to the destruction of the latter doctrine; but this is an error. He labors to show the inadequacy of Mr. Darwin's theory of natural selection to explain organic development; but, as we have said, again and again, Darwinism is not Evolution, and the most eminent evolutionists recognize the tendency to load the law of natural selection with a good deal more than it can carry. Mr. King recognizes that the principle of the "survival of the fittest" is a true principle that has played an important part in organic progress, but which is supplemented by other agencies in the general scheme of Evolution. That Catastrophism is not regarded as fatal to Evolution is at least true of one of its most illustrious representatives, for Mr. King remarks, "Huxley, permeated in every fibre by belief in Evolution, feels that even to-day Catastrophism is not yet wholly out of the possibilities." And speaking of the two theories of unqualified Uniformitarianism and universal Catastrophism (as held by Cuvier), Mr. King declares that he rejects them, and says: "Huxley alone among prominent evolutionists opens the door for a union of the residua of truth in the two schools, fusing them in his proposed 'Evolutional Geology.' Looking back over a trail of 30,000 miles of geological travel, and after as close a research as I am capable, I am impelled to say that his far-sighted view precisely satisfies my interpretation of the broad facts of the American Continent."

In this conception of evolutional geology, Mr. King is led to assign a higher place than has hitherto been allowed to what he terms "evolution of environment," which he regards as a distinct branch of geology that must soon take a recognized form. He assumes a property of plasticity in organisms, by which they are capable of ac-

celerated changes in response to catastrophic disturbances in the environment. Upon this point he remarks:

"It is only through rapid movements of the crusts and sudden climatic changes, due either to terrestrial or cosmical causes, that environment can have seriously interfered with the evolution of life. These effects would, I conceive, be—1. Extermination; 2. Destruction of the biological equilibrium, thus violating natural selection; and, 3. Rapid morphological change on the part of plastic species. When catastrophic change burst in upon the ages of uniformity, and sounded in the ear of every living thing the words 'Change, or die,' plasticity became the sole principle of salvation. Plasticity, then, is that quality which, in suddenly enforced physical change, is the key to survival and prosperity. And the survival of the plastic, that is, of the rapidly and healthily modifiable during periods when terrestrial revolution offers to species the rigorous dilemma of prodigious change or certain death, is a widely different principle from the survival of the fittest in a general biological battle during terrestrial uniformity."

THE LATEST CASES OF HERESY.

The turning out of the Rev. Augustus Blauvelt, of the Dutch Reformed Church, by the Kingston tribunal, for alleged heresy, is one of the things so common nowadays as hardly to excite notice, and we should probably have heard little of this case had it not been that the theological body saw fit to put the trimmings on to the transaction in a way that was not agreeable to the reverend excommunicate. Not content to depose Mr. Blauvelt from his charge for non-conformity to the creed which he had agreed to uphold, they thought it desirable to give the proceeding an extra touch, and so accused him of betraying his Master. Mr. Blauvelt says that, when he found it impossible any longer to accept the creed to which he had subscribed, he would gladly have resigned, but the polity of the society did not allow it; and when they found it necessary to cut him off, he should have recognized the propriety of it, and acquiesced without protest. But when they proposed to "spot" him, and fasten on him the label of Judas, to save other denominations the trouble of looking into his character and belief, if they were so inclined, he did not assent, but appealed to a higher organization. He thought that, if such an outrage as that was to be perpetrated, it had better not be done in a corner, but by the whole responsible body in a conspicuous place, and where dissenters, if any there should be, might have the credit of favoring fair play. In the final issue, twenty-six men voted that the society had nothing further to do than to exscind the teacher who no longer taught approvingly. But ninety men thought differently, and seemed deeply to feel that every fagot, thumb-screw, and dungeon, of the last eighteen hundred years, and all the instruments and agencies of religious conformity, would be dishonored if this writer of independent articles in *Scribner's Magazine* did not get an extra kick at parting—all that the law allows in 1877.

But with these tactics of the Dutch Reformed Church we are not much concerned: what interests us far more is the initial aspect of the case, or that working of the theological polity which at the outset binds the conscience and fetters the thought of all who assume the function of public teachers, in its jurisdiction. The deeper question is one of religious liberty, of the rights of conscience, and the prerogative of independent expression. From this point of view, other recent cases are of interest.

The Rev. Mr. Miller, of Princeton, got into a dangerous way of thinking for himself, about the creed of his church, and, not being pious and politic enough to crush his rising queries as instigations of the devil, had the honesty to announce some conclusions about the mystery of the Trinity which were unpalatable to the Sanhedrim to

which he was accountable; whereupon they suspended him from the authorized ministerial function.

And now there comes report of another case of specially remarkable features, in Scotland. A distinguished divine has been condemned by his church for heresy in contributing a valuable and important article to an influential publication. The great issue comes out here in a conspicuous and somewhat startling way. It is useless to deny that the most remarkable thing about this age is the activity of inquiry, and the progress of knowledge. More and more, people will scan their traditions, overhaul their opinions, and investigate their truth; and every subject upon which they can hold opinions is undergoing this inexorable revision. The consequence is, that errors are sifted out, beliefs that fail to stand the test are gradually corrected, and knowledge is steadily extended. These processes are so real and so rapid that great works, which represent the general state of thought at one time, in a few years require extensive readjustment. The eighth edition of the "Encyclopædia Britannica," which was published in 1857, was a comprehensive and faithful representation of the state of general thought at that time. But the numerous and important advances of knowledge made since have left it so far behind that it became necessary to reconstruct it. This is now being done, and several volumes have appeared. Among other subjects to be dealt with was the Bible; and, strange to say, there has been a great deal of progress and modification of opinion in regard to the origin, interpretation, and history, of this important work, within the last twenty years. The editors were responsible before the world for the honest and faithful treatment of the subject. There could be no flinching from the duty of a thorough statement upon the subject here, any more than in the departments of physical science. Very naturally the ablest and best-equipped student was sought to deal with so delicate and critical a subject. Prof. Robertson Smith, of the Theological Seminary at Aberdeen, was selected for the duty. It cannot for a moment be supposed that a gentleman of position and ability, such as would be chosen for this work, and writing for the thinkers of the world in so distinguished a publication as the "Encyclopædia Britannica," would fail to treat the subject with the severest care, in the genuine spirit of truth-seeking, and with all the honor of the most elevated scholarship. And such is the character of the essay. It is written with masterly ability, and is so full of interesting and important information with which everybody should be familiar, that we shall print it in full in the next number of THE POPULAR SCIENCE SUPPLEMENT. Yet the Free Church of Scotland has been thrown into consternation by the article, and Prof. Smith has been summoned before the General Assembly and suspended, and it is reported that he is to be formally "tried." Meantime, the world will be interested, and will assiduously read the essay.

Now, we call attention to the contrasted policy of Science in the same circumstances. If we turn to the article "Chemistry," in the "Encyclopædia Britannica," we shall see that here also great advance is indicated. There has, in fact, been a revolution so radical and complete, that those familiar with the old statement may find themselves bewildered by the novelty and strangeness of the presentation. Yet nobody hears about any perturbation or alarm in the chemical world, or about Prof. Armstrong being arraigned before the Chemical Society and suspended for heretical teaching.

Obviously there are here two intellectual procedures, which are not only different, but antagonistic. On the one hand, there is recognition that truth is

the supreme end to be sought; that it is yet but partially known; that doubt respecting its received forms, and the subjection of them to the most inexorable tests, is an imperative duty; and that the noblest mental occupation of man is the free exercise of his powers in questioning received beliefs, on any and all subjects, and attaining to clearer, more elevated, consistent, and valid opinions. It is the office of Science to push destructive criticism to the uttermost limit, in every direction of thought, in the steadfast faith that truth will thereby be the gainer, and views more and more clearly established, against which destructive criticism will be powerless.

Accordingly, in every thoroughly managed scientific school in the world, the students are taught, first of all, to be dissatisfied with things as they find them—are trained to skeptical habits in regard to all that of which the proof is not perfect; and are, moreover, especially required to enforce this discipline upon themselves by questioning the evidence of their own results, and by welcoming from any quarter the hostile criticism that shall overthrow the conclusions they suppose themselves to have established. This is, perhaps, an ideal to which but few scientific students fully attain, both because of its essential difficulty, and because scientific education is as yet but a very partial influence in moulding the mind; while the whole force of current and traditional culture is thrown in favor of a very different system of ideals, ethics, and objects, in the work of mental cultivation.

It is very different in the religious sphere. Theology is older than science, and, by the mass of the people, is regarded as a thousand times more important. Theological teachers have been the great pioneers of education in the past, and are still overwhelmingly in the control of it. Among the presidents of our colleges, where there is one man of science there are ten doctors of divinity. A system of education dominated by theology is one which embodies the theological spirit in its methods of culture. What that spirit is, as respects freedom of thought, and the duty of its teachers in the formation of their opinions, we have seen in the recent treatment, by large and authoritative bodies, of Blauvelt, Miller, and Smith. Truth was not permitted to be their object. The right of private judgment, and the consequent right of the free expression of its results, were made crimes to be punished. The liberty to doubt, and from that starting-point to go on to something more true, is not only not encouraged, but is prohibited.

The newspapers, indeed, say, in commenting upon Mr. Blauvelt's case, that the ecclesiastical decision was right, inasmuch as he had violated his engagements with the Church: he agreed to teach certain things, and was bound by his contract. Possibly; but we protest against this degradation of the function of the teacher, especially on the most important subjects, to that of merely carrying out the literal stipulations of a bargain. Commerce may require this, but it is not favorable to the attainment of religious truth. Where would the Protestant Reformation have been, if this theory of religious contracts had been strictly adhered to? And what is the meaning of religious liberty, if those who teach religion are not to be allowed to think? Moreover, as men can no more help thinking than breathing, what is to become of the religious conscience, if they are not allowed to utter what they think?

But granting that men must fulfill their obligations, the deeper question then arises as to their right to assume such obligations. The theological policy being fixed, what right had either Blauvelt, Miller, or Smith, to subject himself to it, so that by the legitimate and independent exercise of his own

mental faculties he should be liable to be cast out of his communion as an heretical culprit? What right had they, or what right has any man, to assume that a statement of doctrine at any time is final, and to enslave themselves to its life-long acceptance? This question is one for theological students, and if the decisions at Kingston, Princeton, and Aberdeen, are to be taken as indicating the authorized policy of the orthodox world, the young man who contemplates entering that field of labor should make up his mind whether he is prepared to cut himself off from the spirit of the age, to abjure the pursuit of truth, and sink into the office of a mere passive repeater of cut-and-dried formulas, prescribed to him by the powers to which he contracts allegiance. He must understand that the less he can have to do with science the safer it will be for him. Its spirit will rebuke him at every step. He will have, moreover, to learn that theological science, so called, is a misnomer and a mockery. Where the scientific element enters, movement begins, and progress ensues. It implies intellectual activity, free questioning, escape from error, and advance to new conclusions, and upon all this, from present indications, there remains the interdict of theological authority, paralyzing free thought, just as it did centuries ago.

We print an essay of Dr. Coues, the naturalist, which will sufficiently vindicate scientific men from the imputation of not doing honor to the regal faculty of imagination. No brain-cracked poet could go further in rhapsodical glorification of the image-making power of the mind than this devotee of observation and induction. What more can be asked to disprove the alleged arrogance of scientists, and to establish their character for humility, than for one of their eminent representatives to go over into the midst of the guardians of all that is most exalted and ennobling in intellectual effort, and say to them, "One excellent and most useful purpose which the imagination subserves at the hands of the gifted few whom the higher development of this faculty makes leaders of thought, and watchful guardians of human progress, is, to put men of science on their proper level, and to teach them to know their place?" Various queries might arise at this point, but as the doctor evidently went over to the literary society to unbend, and have a frolic of fantasy in their direction, he probably thought it not worth while to take his logic along, and spoil the fun. And so nothing remains but to improve his wholesome lesson.

LITERARY NOTICES.

The Cyclopædia of Education: A Dictionary of Information for the Use of Teachers, School-Officers, Parents, and Others. Edited by Henry Kiddle and Alexander J. Schem. Pp. 868. Price (cloth), $5. (Sold by subscription.) New York: E. Steiger,

It is a curious fact that, while the educated class in England and this country have been for a hundred years making cyclopædias on all sorts of subjects for other people, they have only just now succeeded in getting one for themselves. Lawyers, doctors, clergymen, architects, engineers, and farmers, all have their alphabetical summaries of special knowledge for ready reference, until such works have long since come to be indispensable; but only this year have we first got a cyclopædia of education in the English language that will give teachers, school-boards, and all interested in the subject, available and easy command of the wide range of information which bears upon the vocation of instructor. The explanation of this tardiness is not obvious, for no subject is more amenable to this mode of treatment, and certainly none more imperatively requires it. But it does not much matter how long the work was delayed, now that the want has been so adequately and admirably supplied by the work before us. The editors have been equal to their formidable task,

and have laid out the enterprise on a comprehensive and judicious plan, and have brought their own ability and experience, aided by the best talent in the country, to the execution of it.

There is difficulty, in our space, in reviewing a work so elaborate as this, and so packed with attractive statements that one is tempted to read it through like a history; and all we can do is to convey to our readers some idea of the quality and scope of its contents. Among the subjects systematically and prominently treated are: 1. The Theory of Education and Instruction, embracing, under numerous headings, a statement of the principles that have been arrived at by scientific inquiry and practical experience for guidance in the work of teaching. These results apply to all the grades of instruction and training, from the Kindergarten up to the university. 2. The Organization and Management of Schools, including discipline, class-teaching, and the art of instruction, or the general subject of school economy. These topics are considered with the fullness that their obvious importance requires. 3. Careful attention is given to the administration of schools and school systems, embracing supervision, examination, school hygiene, school architecture, etc. 4. State Policy in relation to Education, a subject of peculiar importance in this country, not only because of the extent of legislative control over the subject, but because of the diversity of government action in the different States. 5. Much space is devoted to the history of education, both the general history of school methods and institutions in different parts of the world, and particularly the history of the school systems in the different States and Territories of this country. 6. Biographical Notices of Eminent Educators form a distinct and very attractive branch of the work. 7. The Statistics of Education, or the data of its extent and progress, are comprehensively presented. 8. The subject of Educational Literature forms a very interesting feature of the work, and is ably handled. Of this the editors say: "As the immense mass of material to be condensed within the compass of a single volume has necessitated the greatest possible brevity, references are made throughout to standard works on educational science, as well as to statistical works, affording more detailed information. It is believed that this will prove one of the most valuable features of the work."

Besides these leading topics, which are treated methodically in their various aspects, a great number of miscellaneous subjects pertaining to human culture are so fully presented as to enrich the volume and greatly to increase its efficacy as a reference-book for the teacher. The perusal of various articles, which may be taken as representative, has satisfied us of the painstaking assiduity and excellent judgment of the editors in carrying out the project. They are not only the first in this country to do the work, but they have evidently done it so well that there will be no necessity of again attempting it. "The Cyclopædia of Education" should be in every library, and in the hands of every teacher. We may add that the work is handsomely printed, neatly and substantially bound, and forms an inviting volume that is not too unwieldy for habitual reference. It is sold exclusively to subscribers, and can be had only from the special subscription agents, or from the publisher.

Reconciliation of Science and Religion. By Alexander Winchell, LL. D. New York: Harper and Brothers. Pp. 403. Price, $2.

The question of the relations of science and religion receives a new treatment in this interesting volume. Though the title of his book brings into prominence the idea of peace, or of a terminated conflict, yet the work itself, it must be said, is mainly occupied with the antagonism. The warfare is historic and a living struggle of to-day; the reconciliation a promise of the future. But, in respect to the questions at issue, Dr. Winchell claims to take a non-partisan attitude, favorable to a calm and fair survey of the field of controversy. At any rate, he does not try to end the strife by belittling it. The opposition between religion and science is not illusive; he recognizes its reality, its extent, its importance, and its difficulties. He seems, indeed, to regard it as a part of the great system of conflicts and counteractions in Nature, such as attraction and repulsion,

polar antagonism, centripetal and centrifugal forces. The intellect which gives origin to science, and the sentiment of faith, or instinct of worship, which gives origin to religions, work in opposite spheres, and work against each other by action and reaction in historic periods, which the writer designates as psychic cycles. How deep is this necessity of contest, and how wide its field of operation, in the author's opinion, may be gathered from the following opening passage of Chapter II.: "I have attempted to show that the essential natures of the religious and the intellectual forces in man foreordain a species of antagonism; that this perpetual antagonism is not, nevertheless, an abnormal condition, but a grand example of the universal economy of God, who has ordained antagonism as the condition of progress in the natural and the moral worlds. I have deduced from the necessary relation of the ethical and cognitive powers a necessary series of oscillations in the relative dominance of religious and intellectual influences in the lives of men; and have indicated that the exponent of these oscillations has been, as it must be, a series of alternating periods of religious and of intellectual activity and progress. Such alternations, since the antagonizing forces belong to humanity as such, must characterize the history of all nations, all races, and all times."

He then proceeds "to show that the facts of the religious and intellectual history of the human race illustrate and confirm these deductions, and become in reality a broad inductive basis on which these propositions may be rested as valid generalizations. A prolonged and attentive study of the facts which make up the religious and intellectual history of our race has caused my attention to be directed to the following facts subsidiary to the general induction: 1. Religious faith recedes from its normal condition to one of abnormal subordination, or advances to one of abnormal supremacy; 2. Intellect from its normal condition either advances to a haughty dictatorship or falls into a condition of servitude; 3. These movements of faith and intellect are reciprocal and responsive; 4. The direction of the movement is determined by the initiative: if faith lead in activity, a religious phase succeeds; if intellect take precedence, religious pretensions shrink, and an intellectual phase succeeds. The two phases complete a psychic cycle." Four of these psychic cycles are traced in the course of Christian history.

This is an original and ingenious conception by which Dr. Winchell is enabled to group and arrange the elements of his discussion, historic, religious, philosophic, and scientific, in a very instructive manner for his purpose, and on this account the exposition is certain to be read by general students with interest and profit. Dr. Winchell's work will do especial service, among religious readers, by making the whole discussion, as we might say, a piece of natural history; that is, he treats it in both its aspects, as a part of the method and phenomena of Nature. While holding to the inspiration of the Bible, and the supernatural claims of Christianity, as matters of his own special faith, he nevertheless holds to the validity of the universal religious sentiment in man, and which is as much a subject of rational inductive inquiry as are the physical sciences themselves. We can hardly overrate the gain thus secured, by bringing the whole inquiry into the scientific sphere, and conducting it in the broad judicial spirit which genuine science always imposes.

In one respect, we think Dr. Winchell's work is open to critical objection: it fails to state, as fully as the subject requires, the bearing of the doctrine of Evolution upon the questions in issue. He gives a cautious adhesion to the biological aspect of this theory in the following passage from the preface: "In reference to the much-mooted scientific question of the derivative origin of species, the reader will detect indications of a growing faith. A certain class of proofs has been accumulating at a rapid rate; and the author's present conviction is, that the doctrine of the derivation of species should be accepted."

Now, if the doctrine of descent, as here referred to, is to be accepted at all, it is on the ground of its truth; and, if it be true, it does not stand alone or as a proposition with which we have no further concern than simply to approve or reject it.

If the origin of species by derivation is established, it goes a great deal further and gives us the origin of many more things. It must be taken as an indication of the plan of Nature, of which man is a part, so that the career of humanity is at once brought under the law of development. If there be truth in evolution, we are bound to go by it; and if man's religious nature has had an unfolding, like the other elements of his being, that fact must certainly be of the greatest moment in determining the relations of religion and science. As to harmony or conflict, the question at once arises at what stage it is taken, and what are the traits of that change in which man's religious progress consists. Dr. Winchell, as we have said, affirms the universality of the religious element in man, and deduces its validity from its universality, but he ought to have eliminated from it the transitory, or what can be outgrown, and told us what there is about it that is essential and permanent, and to be finally harmonized with science. He enumerates the following as the grand facts common to the religious faiths of the world: 1. A Supreme Being, the author of all things in existence; 2. A revelation of the Supreme Being either in sensible things or in the intelligence of inspired men; 3. A system of worship—which is either instinctive and aimless, or intended to propitiate the Deity and win happiness for the worshiper; 4. Prayer, the universal cry of humanity in distress; 5. Future existence; 6. Moral responsibility; 7. A system of future rewards and punishments; 8. A priesthood charged with the direction of religious ceremonies, and clothed with a special investiture of divine authority and power. He says: "These facts I find to be the constants in the varying faiths of mankind. I will add that two other facts reveal themselves in *most* of the religious systems of the world—both the greater and the less. These are: 1. A belief in the efficacy of vicarious expiation; 2. An expectation of a Redeemer."

These are, no doubt very widely-spread beliefs, but they have had very different meanings among different races, and at different times. In this field, preëminently, we are familiar with the decay of the vital core of beliefs, and the conversation of their formulas, but what we want most to know is, the laws of change, transformation, and expansion of religious ideas, in relation to man's intellectual development — what falls away and what survives. Dr. Winchell recognizes the progress, and gives us the final result, in a form so generalized, that we can only find the constants just named by some stretch of implication. He says: "The next psychic cycle, it seems to me, will witness a synthesis of thought and faith—a recognition of the fact that it is impossible for reason to find solid ground that is not consecrated ground; that all philosophy and all science belong to religion; that all truth is a revelation of God; that the truths of written revelation, if not intelligible to reason, are nevertheless consonant with reason; and that divine agency, instead of standing removed from man by infinite intervals of time and space, is, indeed, the true name of those energies which work their myriad phenomena in the natural world around us. This consummation—at once the inspiration of a fervent religion and the prophecy of the loftiest science—is to be the noontide reign of wedded intellect and faith, whose morning rays already stream far above our horizon."

Turkey. By James Baker, M. A. New York: Henry Holt & Co. Pp. 495. Price, $4.

The problem of the Turkish Empire, the great anomaly in European civilization, has long occupied the attention of those interested in international politics—an interest greatly heightened, of late, by the Russian invasion of Turkey, and the threatened complication of other states in the struggle. To those whose solicitude about the Oriental question leads them to inquire into the condition of the people most deeply concerned the present volume will be eminently welcome. We lately called attention to Mr. Wallace's admirable book on "Russia." Colonel Baker's volume gives us a corresponding picture of Turkish life and character, the political institutions, religious peculiarities, and material resources of the empire. The book is full of very interesting information upon this class of subjects, much of which is fresh, and calculated to

dispel erroneous impressions, and many unjust prejudices that are entertained in Christian countries, concerning the Turkish people. Turks are known to the outside world chiefly through their government, which is bad and corrupt, and shamefully misrepresents the population which it rules. After sketching some historic features of Turkish character in former times, in Chapter VIII., Colonel Baker goes on to say:

"There is one point in common with both the past and the present, and that is that the Turkish rank and file, the real pith of the nation, were then, as now, distinguished for their patience, discipline, sobriety, bravery, honesty, and modesty, and to these qualities I may also add that of humanity, although I know it will excite an indignant exclamation from many at the present moment. But look at the Turkish soldier in private life, and you find him gentle and kind to children and women, and exceedingly fond of animals. His first thought after a long and tiring day's march is his horse. As soon as he has made the animal comfortable, then he thinks of the man. When he is exasperated by what he thinks insults to his creed, he kills and slays as his teaching tells him, and he appears a fanatical madman; but he is then outside his real nature, and not within it. It is but the other day that I saw thirteen thousand of these brave men arrive fresh from the front and all the hardships of the Servian campaign. They were billeted for ten days all over the town of Salonica, and there was not a single complaint, or cause for complaint of their conduct, from man, woman, or child.

"The streets, although filled with soldiers, were as quiet as in ordinary times. What other troops *in the world* would behave in such an admirable manner? Read the greatest authorities on the subject. Von Hammer, Gibbon, Boné, Ubicini, Creasy, and all agree in praise of both the past and present character of the Turkish rank and file. But it is the rank and file that depicts the character of the nation, and not the corrupt oligarchy, which from its prominence misrepresents it. We find, then, that the rank and file of the Turkish people is the same now as ever, so that it is not the nation but the rulers which have changed, and this change has been brought about through the corrupt influences which were handed over to them by the Byzantine Empire.

"As soon, therefore, as the head of the Turkish nation shall be purified, we shall find the whole constitution in a healthy state—there is no disease of the body. The combination in Turkish government of despotism with the freedom of the most democratic of republics is unique. In Turkey there is no aristocracy. All men below the sultan are equal, not only in the eyes of the law, but by creed and custom. A shoeblack may be made grand-vizier, and it is by no means uncommon to see some of the highest officials of the state who have been servants to predecessors in office."

The volume is written in a pleasant, unambitious style, the writer's object being evidently to tell the story of the Turks in a plain, direct, and instructive way.

Elementary Chemistry: A Text-Book for Beginners, designed as an Introduction to Barker's Chemistry. By S. F. Peckham, A. M. Pp. 254. Price, $1. Louisville, Ky.: John P. Morton & Co.

This is a neatly-bound, neatly-printed, and neatly-illustrated school-book, designed for beginners; and the author says that his "object has been to supply a work for elementary schools which should be as nearly as possible equal in quality to the text-books of Barker and Eliot and Storer." He could not have taken better models. A peculiarity of the book is, that the work of learning and instruction is carried on by the artifice of conversation between Harry, George, Lucy, and Uncle Louis, which raises the question whether much of their talk is worth the space given to it. The illustrations run into the pictorial, regardless of the publisher's purse, and it is an aim of the writer to make the book introductory to agricultural studies.

The Forces of Nature: A Popular Introduction to the Study of Physical Phenomena. By Amédée Guillemin. Translated from the French by Mrs. Norman Lockyer, and edited, with Additions and Notes, by J. Norman Lockyer, F. R. S. Illustrated by nearly 500 Engravings. Part I. Pp. 40. Price, 40 cents. London: Macmillan & Co.

The great success of the elaborate volume under the foregoing title, both in France and England, has induced the publishers to enter upon its reissue in parts, with the view of cheapening it, and bringing it to the attention of a wider circle of readers. It is hardly necessary to repeat what we said in reviewing it, that the book is superbly illustrated, and is very clear and popular in the style of its text. It will be completed in eighteen parts.

Transactions of the Wisconsin Academy of Sciences, Arts, and Letters. Vol. III. 1875–'76. Pp. 269.

This volume of 269 pages comprises twenty-four papers read before the Acad-

emy, of which thirteen were read before the department of the natural sciences. Several of these illustrate the geology and natural history of Wisconsin, but are of general as well as of local interest. Others give the results of archæological researches in the State, with several illustrations.

The departments of letters, of the social and political sciences, and of speculative philosophy, are represented by papers of ability from specialists in the respective departments. A paper on recent progress in theoretical physics by Prof. John E. Davies, of the University of Wisconsin, is an able *résumé* of researches on that subject.

A summary of proceedings of the Academy since 1874 is given, and not the least interesting portions of the volume are memorials commemorating the labors and worth of two deceased members, the late Prof. Peter Engelmann, and the eminent Dr. J. A. Lapham, first secretary of the Academy.

A Course of Lessons in Modeling Wax Flowers, designed especially for Beginners. By Florence I. Duncan. With Illustrations. Philadelphia: J. B. Lippincott. Pp. 94.

This little book is intended as a practical guide to the art of modeling flowers in wax. The author aims to give such explicit directions for the selection of materials, and their proper manipulation, that a novice in the art can acquire dexterity in the management of wax for this purpose. It is well gotten up, is attractive in its general appearance, is printed on fine thick paper, and illustrated by seven full-page engravings of flowers suitable for models.

Catalogue of the University of Cincinnati for the Academic Year 1877–'78. Pp. 104. Office of the University.

This young institution gives indications of vigorous life and thorough-going management. Its scientific department, especially, is administered with ability. Chemistry, for example, is not only taught in the sense of imparting existing knowledge, but the students are early called upon to address themselves to original and independent work. There are gaps, unsettled points, contested questions, and doubtful results, in such abundance in this science that there is no difficulty on the part of the intelligent teacher in assigning problems suited to various capacities and steps of advancement, or in combining a class upon any suitable line of investigation. Prof. F. W. Clarke, who has charge of physics and chemistry, has arranged a course of preparative work along the track of chemical physics, which is well fitted to train the students to habits of accurate manipulation, and to stimulate them in the direction of original thought. One feature of his plan is thus presented:

"In connection with the other laboratory exercises, a certain amount of time will be spent in making fine chemical preparations, and in determining densities. In 1877–'78 this portion of the course will be so arranged as to involve the coöperation of all the laboratory students in a systematic research upon the constitution of double salts. Each student will be required to prepare a number of such salts, and to determine, by means of the specific-gravity bottle, the amount of condensation which takes place during their formation. At the end of the year the entire mass of material thus collected will be discussed both by the student and by the professor, and as much of it as proves to be valuable will be published in some one of the scientific journals. The aim of this exercise is to give every student some insight into the methods pursued by scientific investigators, and to demonstrate the important principle that whoever is able to study science at all is also able to contribute something toward its advancement."

The Anonymous Hypothesis of Creation. By James J. Furniss. New York: Charles P. Somerby. 1877. Pp. 54. Price, 50 cents.

In this review of the Mosaic cosmogony, the author aims at presenting the subject as concisely as practicable for the benefit of those who have not the time or the inclination to peruse more voluminous works. The first and second chapters of Genesis are dissected and compared, and their supposed incongruities are rendered more obvious by being presented in tabular form.

A Calendar of the Dakota Nation, by Brevet Lieutenant-Colonel Garrick Mallery, U. S. A., from the Bulletin of the United States Geological and Geographical Survey. Pp. 25.

Colonel Mallery, with the assistance of Lieutenant Reed and others, whose services are acknowledged, has presented a valuable paper, with a lithographic copy of the Dakota calendar. The original is on

cotton cloth, and represents, by a series of symbols, events in which the Dakotas were concerned, beginning about the year 1800. Each year is represented by a symbol, the meaning of which is explained in the text. The symbol for 1800 is thirty black lines, representing that thirty Dakotas were killed that year. The symbol for 1801 is the head and body of a man covered with red blotches; that year the small-pox broke out in the nation. In 1869 the sun was eclipsed; the symbol representing it is a black disk. The calendar is of value as "an attempt, before unsuspected among the nomadic tribes of American Indians, to form a system of chronology."

The Development of the Animal Kingdom: A Paper read at the Fourth Meeting of the Association for the Advancement of Woman. By Graceanna Lewis. Pp. 21.

This paper is an attempt to show that there exists an "order of relationship" in the animal world, and that, beginning with the lowest organisms, there has been, up to the highest forms, an "order of development." The facts which recent paleontological researches have brought to light are used by the author with considerable skill in illustration of her subject.

Personal Immortality, and Other Papers. By Josie Oppenheim. New York: Charles P. Somerby. Pp. 98. Price, $1.

This little work is by an avowed free-thinker, who, in a few pages of prefatory remarks, tells us in a very candid way why she thinks such a book is needed, and what she hopes to accomplish by it. Then follow discussions of "Personal Immortality," "Materialism," "Prayer," etc. The spirit of the writer is good, and, whether readers agree with her views or not, they cannot deny her sincerity or fail to be gratified by her tolerance.

Western Diptera. By C. R. Osten-Sacken. From the Bulletin of the United States Geological and Geographical Survey, Vol. III., No. 2. Pp. 164.

Very little was known of the diptera of the Pacific coast until the publication of this report. Collections were made by the author in California during the years 1875 and 1876, not only along the low plains, but on plateaus of the Sierra Nevada region, at elevations of from 6,000 to 8,000 feet above the level of the sea. The present volume is a survey of the collections made, which the author says are, after all, but a small fragment of the fauna collected during a limited season. The descriptions of families and species are full and clear, and the volume, which comprises 165 pages, will be prized as a valuable contribution to American entomology.

Report on the Mineral Wealth, Climate, and Rainfall, and Natural Resources, of the Black Hills of Dakota. By Walter P. Jenney, E. M., Geologist in charge. Pp. 71.

This report, published in 1876, comprises Chapters V., VI., and VII. of the forthcoming final report of the exploration of the Black Hills, made under direction of the Commissioners of Indian Affairs, in 1875.

The area of the Black Hills is stated to be nearly 6,000 square miles, about two-thirds of which area is in Dakota, the remainder in Wyoming. They are separated from the main chain of the Rocky Mountains, and surrounded by level or rolling plains. The mineral and agricultural resources, climate, rainfall, water, forests, etc., of the Black Hills region are presented in considerable detail. A good map accompanies the report.

First Annual Report of the Ohio State Fish Commission. Columbus: Nevins & Myers, State Printers. 1877.

In this report is given a detailed and very interesting account of what has been done by the Ohio State Fish Commission to promote the culture of fish in that State. Hatcheries have been established at Castalia Springs, Toledo, Cleveland, and Kelley's Island, at all of which places the hatching of fish has been successfully carried on. The report is greatly enhanced in value by numerous illustrations, which are accompanied by very full descriptions, copied from the manuscript of Prof. Jordan's forthcoming report on the zoölogy of Ohio. The report includes a catalogue of the fishes of the State.

Shade-Trees, Indigenous Shrubs, and Vines, by T. Stewart, M. D., and Insects that Infest Them, by Miss Emma A. Smith, Entomologist. Peoria, Ill.: Transcript Company. 1877.

This pamphlet was prepared for the region about Peoria, Ill., but contains much that will be of value elsewhere. It gives a brief account of the indigenous trees and shrubs best adapted to the locality, and the paper by Miss Smith treats of the insects which infest them, of which figures are given. Publications like this do excellent service in directing public attention to the cultivation of trees and the planting of forests.

Science-Lectures at South Kensington. London and New York: Macmillan.

Under the above general title Macmillan & Co. have published a series of small volumes containing lectures delivered at the South Kensington Museum during the loan collection of scientific apparatus last year. One of the volumes contains two lectures by Prof. Roscoe on "Technical Chemistry," the first treating of the manufacture of sulphuric acid, and the second of the alkali manufacture. In another volume are two lectures by Prof. Stokes, on "Absorption of Light and the Colors of Natural Bodies," and on "Fluorescence." The third volume of the series contains two lectures on the "Steam-Engine," by F. J. Bramwell. Finally, there is a volume entitled "Outlines of Field Geology," by Prof. Geikie. These lectures are all addressed to science-teachers, and not to popular audiences; hence they are rather technical, and possess an interest for the practical student of science rather than for the general reader. The prices are: for the first two volumes, 20 cents each; for the other two, 25 cents.

J. W. Bouton announces "Isis Unveiled: A Master-Key to the Mysteries of Ancient and Modern Science and Theology," by H. P. Blavatsky, Corresponding Secretary of the Theosophical Society. This work is announced as a philosophical study of Orientalism, by a native of Asia, whose life has been passed in the study of traditions, languages, literature, mythology, philosophy, and mysticism, of Eastern peoples, and who considers Oriental thought and history with reference to modern ideas. The work is to be issued in two large octavo volumes.

PUBLICATIONS RECEIVED.

Narrative of the Polaris Expedition. By Rear-Admiral C. H. Davis. Washington: Government Printing-Office. Pp. 696. With numerous Plates.

Hand-book of Descriptive Astronomy. By George F. Chambers. London and New York: Macmillan. Third edition. Pp. 960. Price, $10.

History of Protection in the United States. By W. G. Sumner. New York: Putnams. Pp. 64. Price, 50 cents.

Lists of Elevations West of the Mississippi. By H. Gannett. Washington: Government Printing-Office. Fourth edition. Pp. 164.

The Tailed Amphibians. By W. H. Smith. Detroit: *Herald* print. Pp. 158.

Eighth Annual Report of the Massachusetts Board of Health. Boston: Wright print. Pp. 523.

Bulletin of the Geological and Geographical Survey of the Territories. Vol. III., No. 3. Washington: Government Printing-Office. Pp. 200.

Relations of the Public School to the Negro. By Civis. Richmond: Clemmitt & Jones print. Pp. 39.

Scientific Basis of Delusions. By Dr. G. M. Beard. New York: Putnams. Pp. 47. Price, 50 cents.

Pennsylvania College Monthly. Gettysburg: Wible print. Pp. 36. Price, $1.25 per annum.

Semicentennial Anniversary of Prof. J. W. Jackson at Union College. Albany: Munsell print. Pp. 32.

Reply to a Printed Circular. By Dr. J. Marion Sims. New York: Kent & Co. print. Pp. 24.

Influence of Physical Condition on the Genesis of Species. By J. A. Allen. From the *Radical Review*. Pp. 32.

Twenty-eighth Annual Announcement of the Woman's Medical College of Pennsylvania. Pp. 20.

Recent Progress in Sanitary Science. By A. R. Leeds. Salem Press print.

Papers on the Coryphodontidæ, the Odontornithes, and a Gigantic Dinosaur. By O. C. Marsh. From *American Journal of Sciences*. With Plates. Pp. 8.

Responsibility in Parentage. By Rev. S. H. Platt. New York: S. R. Wells & Co. Price, 10 cents.

Geological History of Cayuga and Seneca Lakes. By C. W. Foote. Ithaca, N. Y.: Norton & Conklin print. Pp. 14.

A Case of Recurring Sarcomatous Tumor. By Thomas Hay, M. D. Philadelphia: Lindsay & Blakiston. Pp. 14. With Lithographic Plates.

Second Stenografik Teecher. Amherst, Mass., U. S. A.: J. B. Smith.

Chemistry of Hydrogen. Also, Reduction of Silver. By A. R. Leeds. New York: Trow & Son print. Pp. 23.

Surgical Anatomy of the Tibio-tarsal Articulation. By Dr. J. A. Wyeth. From *American Journal of Medical Sciences*. Pp. 12.

Directory of the Spiritualism of the Bible. By Susan A. Vandyke. Pp. 4.

Ornithology of the Red River of Texas. By C. A. H. McCauley. Pp. 40. American Insectiv-

orous Mammals. By Elliott Coues. Pp. 22. Bulletin of the United States Entomological Commission. No. 2. Pp. 14. Washington: Government Printing-Office.

The Plants of Wisconsin. By G. D. Swezey. Beloit: *Free Press* print.

POPULAR MISCELLANY.

Scientific Associations for 1877.—The French Association for the Advancement of Science will this year hold its sessions in August, at the city of Havre, under the presidency of Dr. Broca, the eminent archæologist. The Geological Society of Normandy will give an exhibition of the geological and paleontological products of that ancient province.

The annual meeting of the British Association will be held at Plymouth, on August 15th; Prof. Allen Thomson, President. The officers of the Association hope to be supported by the personal assistance and written contributions of philosophers of other countries, and they undertake to make preparation for the reception of the distant friends and associates who may give notice of their intention to be present at the meeting.

The officers of the American Association for the next meeting, which is to be held at Nashville, Tennessee, commencing on Wednesday, August 29th, are Prof. Simon Newcomb, President; Prof. Edward C. Pickering, Vice-President of the Physical Section; Prof. O. C. Marsh, Vice-President Section of Geology and Natural History; Prof. N. T. Lupton, chairman of the Chemical Subsection; Prof. Daniel Wilson, chairman of the Subsection of Anthropology; R. H. Ward, chairman of the Subsection of Microscopy; A. R. Grote, General Secretary; F. W. Putnam, Permanent Secretary; William S. Vaux, Treasurer.

Shad in the Ohio River.—Mr. Spencer F. Baird, of the United States Fish Commission, in a letter to the editor of *Forest and Stream*, states that he has received a few specimens of a genuine white shad, four pounds in weight, taken from the Ohio River at Louisville, Kentucky—a direct result from the efforts made by the commission to stock the western rivers with shad. The letter gives a brief account of the work done by the commission toward introducing the shad into the waters of the Western States, beginning with 1872, when Seth Green planted 30,000 young shad in the Alleghany at Salamanca, New York, and 25,000 in the Mississippi near St. Paul. Later in the same year, the Rev. Mr. Clift placed 200,000 in the Alleghany at Salamanca, and a small number in the Cuyahoga and in the White River at Indianapolis. The same gentleman carried 2,000 young shad as far west as the Platte, at Denver. In 1863 about 160,000 shad were placed in the Greenbriar and New Rivers in West Virginia, and about 55,000 in the Monongahela in Pennsylvania and the Wabash in Indiana. Mr. Baird has been informed that for some considerable time forty to fifty shad have been taken daily at Louisville by a drag seine said not to exceed thirty or forty yards long, and that in the shoaler water of only three or four feet, while the regular steamboat-channel is ten or twelve yards deep and 250 yards wide.

A Remarkable Salt-Bed at Goderich, Ontario.—Dr. T. Sterry Hunt gave, at the late meeting of the Institute of Mining Engineers, an account of the layers of rock-salt in the geological strata of Goderich, Ontario, as developed by a boring recently made. The paper has been published in the *Engineering and Mining Journal*, from which we quote some particulars regarding two of the most important rock-salt beds reached in the course of the boring. A bed of rock-salt of exceptional purity was found at the depth of 1,060 feet, and another bed, not so pure, at the depth of 1,092 feet. Of these, the former is 25 feet thick and the latter 34 feet; they are separated from each other by a layer of less than seven feet of rock, and for practical purposes may be regarded as one. The amount of foreign matter contained in the twenty-five-foot bed is singularly small, being less than a quarter of one per cent. Its remarkable purity is seen on comparing this with the best commercial salts. Thus, Cheshire rock-salt contains of foreign matter 2.67 per cent., and the famous rock-salt of Cardona, Spain, 1.45 per cent. of impurities.

The salts got by evaporation from sea-water and from brines, with which our markets are in great part supplied, contain nearly

as much impurity. "From data gathered by me," says Dr. Hunt, "and published some years since in a 'Report of the Geological Survey of Canada,' it appears that the amount of foreign matters in Turk's Island salt is 2.34; in Saginaw salt, 2.00; in Syracuse solar salt, 1.15; and in the boiled salt from the same locality about 1.50 per cent. Of the salt made at Goderich from the brines pumped from the salt-bearing strata of the region, three samples, analyzed by me in 1871, gave: for coarsely crystalline salt, 1.097; flaky medium salt, 1.282; and fine salt, 1.625 per cent. of foreign impurities. The fine salt, which is the least pure, is made by boiling, the others by slower evaporation. The analysis by Dr. Goessmann of another sample of Goderich boiled salt gave 1.50; while the rock-salt from the layer of $10\frac{3}{4}$ feet in Division VIII. of the section [the twenty-five-foot layer mentioned above] contains only 0.234 per cent., or less than one-sixth of the amount of foreign matter found in the boiled salt made from the Goderich brines."

About the English Sparrow.—A spirited but entirely courteous controversy is being carried on in the columns of our contemporary, *Forest and Stream*, about the English sparrow. The principal questions in dispute are whether this bird is useful as a destroyer of noxious insects, worms, and the like, and whether it banishes from its haunts all other species of small birds. The evidence is conflicting. Some of the writers say of the sparrows that they are "exceedingly quarrelsome among themselves," and intolerant of birds of a different species. When a stranger-bird makes his appearance among them, the fury of the whole sparrow community is turned upon him; they chase him hither and thither, giving him no rest until he is banished from the neighborhood. "They" (the sparrows) "let the orchards go to ruin," we are told, "for they will not eat every kind of insect." One writer sums up the case against the sparrows thus: 1. They have no personal attractions except their tameness; 2. They are practically useless; they may have been useful on their first arrival from Europe, but they are too much pampered to be so now; 3. They destroy fruit-blossoms; 4. They are often quarrelsome, and sometimes drive away useful birds. On the other hand, we are told that the sparrows destroy immense numbers of larvæ, especially during the winter; that they are *not* hostile to other birds; that they do not destroy fruit-germs. A writer who lives in Tenafly, New Jersey, says: "We have a few sparrows in the yard, and find their presence makes very little difference with the other birds. We have sixteen varieties of birds in the yard at this writing, viz., brown thrush, robins, catbirds, orioles, wood-robin, bluebirds, phœbe-bird, cuckoo, kingbird, and the rest warblers of different kinds. We find the most quarrelsome to be the kingbird and black oriole. These last are chasing almost everything that crosses their path."

Hygiene of the Eyes.—A series of questions touching the care of the eyes were recently submitted to Dr. E. G. Loring, Jr., by the Medico-Legal Society of New York. Dr. Loring replied in a paper which has since been published in the *Medical Record*. To the first question—namely, whether bad air has any direct effect on the sight?—the author replies that vitiated air has a specially irritating influence on the mucous membrane of the eye; and that bad air, as a primal cause, may set in train morbid processes which not only will affect the working capacity and integrity of the organ, but may even lead to its total destruction. The second question was, whether size and quality of type may cause disease of the eye? According to Dr. Loring, the smallest print which a normal eye can readily recognize at a distance of one foot is about $\frac{1}{50}$ inch, and at eighteen inches' distance about $\frac{1}{32}$ inch. The normal eye should never be subjected for any length of time to a type smaller than twice this size, or $\frac{1}{16}$ inch, and it would be better, after middle-life, to employ a type even a little larger than this; but the employment of spectacles removes in a great degree the necessity of a larger type with advancing years. The finer the type, the closer the book has to be held to the eye, and the greater the demand on the focalizing power and the muscles that bring both eyes to bear at once upon the print. On the other hand, too coarse type is wearisome to the

eye, requiring more exertion of the muscles that govern the movements of the eye. The distance between the lines should be about one-eighth inch; nearer than this is apt to be confusing, farther apart is also confusing. Heavy-faced type is preferable to light-faced. An almost imperceptible yellow tint in the paper, "natural tint," is very desirable; pure white paper, especially if it has a metallic lustre with bluish tinge, should not be employed. The paper should be thick enough not to be transparent, should have a close, fine texture, and be free from sponginess. To the third question—whether too long and constrained attention to one object, without rest or variety, will cause eye-disease?—Dr. Loring replies affirmatively, and assigns the physiological reasons. Finally, he was asked whether the angle at which light strikes the eye is important? He replies that the light should not come directly in front; neither should it come from directly behind. It should not come from the right side, because, in writing, the shadow of the hand falls across the page; and a moving shadow over a lighted surface not only reduces the quantity of light and leads to a stooping position, but it is also more annoying to the eye than a uniform reduction in the illumination of even a greater degree. The best direction for the light to come is from the left-hand side, and from rather above than below the level of the hand.

High Temperatures and Bowel-Complaints.—Dr. N. S. Davis, in a "Report on Clinical and Meteorological Records" communicated to the American Medical Association, an abstract of which we find in the *Medical Record*, reaches the conclusion that the bowel affections, so characteristic of this temperate climate, begin invariably with the first week of continuous high temperature, and that every subsequent occurrence of several days and nights of continuous high temperature causes new attacks to be increased in number throughout the month of July, less in August, and still less in September; that it is not simply the extreme of heat, but its duration, which determines the number of attacks; that this continuous high heat, to be efficient in producing these affections, must follow a protracted season of cold; and that, if we compare these deductions directly with statistics of mortality, we shall find them to conform in every particular in that the high rate of mortality follows exactly the same line. That fact was regarded as one of great importance in connection with sanitary measures which were to be adopted for the protection of life in infants; preventive measures must strike with the first week of consecutive high temperature. These conclusions were corroborated by quotations from mortality-tables.

Manurial Value of Spent Tan and Sawdust.—From careful analyses of spent tans and dyewoods and other similar waste materials, Prof. F. H. Storer, of the Bussy Institution, reaches the general conclusion that they contain but a very small proportion of fertilizing substances, and that practically, whether they be fresh or rotten, they have very little value as manure. Of fresh sawdust, even that from hard woods, he says that it can hardly be considered an economical manure; it is far inferior, for compost, to peat. But, curiously enough, the chemical evidence goes to show that it is for feeding animals rather than for feeding plants that sawdust might be put to use. Fresh sawdust, even that of pine-trees, can be used with advantage as fodder in times of dearth. Twigs and leaves, as the clippings of vines and hedges, or bushes mown in pastures, are undoubtedly valuable both as manure and forage. Autumn leaves and the rakings of woodland, which consist for the most part of leaves that have not only fallen, but have been bleached by rains, may be classed as somewhat inferior to straw.

Wearing Qualities of Aluminium.—The comparative resistance of aluminium to change of color and wear, when brought into daily use, has been made the subject of observation by Dr. C. Winkler, of Freiberg, who finds, according to the *Polytechnic Review*, that it is inferior to silver in retaining color and lustre, being about on a par with German-silver in these respects; while it wears away more rapidly than silver, but less so than German-silver. Spoons made of all three materials, each having exactly the

same weight, were used a year under precisely similar conditions, being placed in the same soups, sauces, sour salads, etc., and exposed alike to hot, acid, and alkaline solutions, and subjected to similar methods of cleaning. The aluminium turned to a dead bluish-gray color, and lost its lustre; the German-silver changed to a grayish-yellow; the silver lost only in color, retaining its lustre. Weighed at the end of the year, the silver spoon had lost 0.403 per cent., the aluminium spoon 0.630 per cent., and the German-silver spoon 1.006 per cent. For small coins, Dr. Winkler thinks that aluminium is to be preferred to either nickel or silver alloys.

Is Insanity on the Increase?—Do the conditions of human life, as they exist in modern civilized countries, tend to an increase of insanity? A glance at the statistics of the insane for any given country would seem to require an affirmative answer to this question. For instance, the ratio of insane persons in England in the year 1859 was 18.67 to 100,000 persons; in 1865 it was 21.73; in 1870, 24.31; in 1876, 26.78. In other words, there is now one insane person to 375 of the population, while in 1859 the proportion was about one in 540. But, as is shown by Dr. Henry Maudsley, in the *Journal of Mental Science*, the increase is apparent only: more insane persons are *registered* now than formerly. Again, the establishment of numerous asylums, and the better care bestowed on patients, have had the effect of prolonging the lives of the insane; this, too, will in part account for the higher proportion of insane shown by the statistics. The question is incidentally raised by Dr. Maudsley, whether we *cure* more insane persons nowadays, when we treat them well, than our uninstructed forefathers cured when they treated them ill. "There is," he replies, "no evidence that we do." Here the statistics *would seem* to show that, under the old system, there was a higher percentage of recoveries. "Yet, it would be wrong," remarks the author, "to attribute the lower percentage of recoveries to the ill-success of our present mode of dealing with insanity; it is, no doubt, owing in great part, if not entirely, to the greater proportion of chronic and incurable cases among those who have been admitted during the last twenty-five years. Formerly, acute and violent cases only were sent to asylums, and they would yield a larger percentage of recoveries, as well, probably, as a larger percentage of deaths. Of the admissions fewer recover and fewer die each year now than then, the result being the steady accumulation of a residue of chronic and incurable insanity beyond what occurred then. It is a question," he adds, "deserving attention, whether the present practice of crowding the insane of all sorts into large asylums, where the interests of life are extinguished, and where anything like individual treatment is wellnigh impracticable, is so much superior to the old system in effecting recoveries as some persons imagine."

The Rocky-Mountain Locust in Manitoba.—The following notes on the appearance and migration of the locust in Manitoba and the Northwest in the summer of 1875 are taken from a notice, in the *American Journal of Science*, of a paper on that subject by George M. Dawson. In the year just mentioned the hatching of locusts began in Manitoba on May 7th, and on May 15th it was general. The movement began in July, and was most general during the latter half of that month and the early part of August. The direction was southeast or south. Other swarms of locusts came from the south across the forty-ninth parallel, with a wide front stretching from the ninety-eighth to the one-hundred-and-eighth meridian; these arrived before the Manitoba broods were mature. These were the extreme northern part of the army, going northward and northwestward from the States ravaged in the fall of 1874. Mr. Dawson thinks that the planting of belts of woodland would in time effect a general and permanent abatement of the grasshopper-plague, since they usually avoid such belts. Their journey southward was regardless of the direction from which their parents had come the preceding year; and those of Nebraska, Missouri, Kansas, and Texas, flew northward and northwestward, returning on the course of their parents, who had flown southeastward from that quarter. The normal direction of flight is

toward the hatching-grounds of their parents, so that two years seem to be required to complete the migration cycle. The methods of prevention proposed are the cultivation and preservation of forest-trees; the protection of the prairie-grass till the appropriate time for destroying the young insects by fire; and the protection of insect-catching birds.

A New Wheat-Fungus in California.—Early in March of the present year the young wheat in certain districts of California began to exhibit on its expanded leaves yellowish-white patches of fungous growth. This peculiar species of "rust" or "mildew" appears to be new to California, and has been recognized by Mr. H. W. Harkness, of the San Francisco Microscopical Society, as the *Erysiphe graminis* of De Candolle. According to Mr. Harkness, the fungus appears on the expanded leaves in felt-like patches, from one-sixteenth to one-half inch in length, following the longest diameter of the leaf equally on both sides. It adheres with great tenacity, though, on examining sections of the leaf and fungus, no suckers are apparent. The leaf, at a short distance from the culm, soon turns brown and dries. In the earlier stages the mycelium is observed creeping over the surface, its filaments overlying one another until it forms a felted mass. To what extent the wheat will be damaged, it is as yet impossible to say. Adhering, as it does, closely to the plant, it doubtless appropriates the juices needed for maturing the grain, at the same time excluding air and sunlight from the tissues. Its visible effect is a weakening of the stalk, thus favoring decay.

A New Measure of Geological Time.—The amount of solid matter abraded from the land and carried to the sea as sediment, or in suspension, has often been estimated by geologists, and the importance of this suspended matter as an agent of geological changes has been fully recognized. But less attention has been bestowed upon the soluble matter washed out of the earth by every fall of rain and added to the waters of the ocean. This subject has been studied by Mr. T. Mellard Reade, whose results, as set forth in his presidential address to the Liverpool Geological Society, we find summarized in the *Nineteenth Century* as follows: The author's first problem was to estimate the total quantity of solid material removed in the course of one year, by the solvent action of rain, from the entire surface of England and Wales, supposing the mean rainfall to be thirty-two inches. It is worthy of note that the variation of rainfall in different parts does not affect the quantity of dissolved matter to anything like the extent that might have been anticipated. True, the hilly districts of the west, in Cumberland, Wales, Cornwall, and Devon, intercept a large quantity of rain; but, then, these collecting-grounds are composed of old rocks, ranging from Cambrian to Carboniferous; and such rocks are, to a great extent, insoluble. On the other hand, in the southern and eastern counties the rainfall is much less than in the west; but, then, the rocks belong generally to Secondary and Tertiary formations, and are tolerably soft and soluble. A kind of compensation is thus established, the total quantity of solid matter carried off in solution in a given time being much the same in one river as in another. Roughly speaking, it may be said that where the rainfall is greatest the solubility is least; where the rainfall is least the solubility is greatest. It is needless to follow the details of the calculation by which the author is finally led to the conclusion that about 8,370,630 tons of solids are annually removed in solution by the rivers of England and Wales. Distributing the denudation equally over the country, the total area being 58,300 square miles, we obtain a general lowering of the surface to the extent of .000077 of a foot in a single year; in other words, it would require 12,978 years to reduce the surface of England and Wales by one foot through the solvent action of rain alone. Fewer data exist for extending this interesting inquiry to the Continent of Europe, and fewer still when we pass to other parts of the world. But, making the best of available data, and proceeding on the principle that "Nature, on the whole, averages the results," Mr. Reade feels justified in assuming provisionally that about one hundred tons of rocky matter will be dissolved by

rain from every English square mile of the solid surface of the earth in the course of a year. All this dissolved matter, however far it may be transported by rivers, ultimately runs down into the sea. If, then, as commonly supposed, the sea contains only what has been washed out of the land, the results previously attained may help us to form some crude idea of the length of time which has been needed to give the ocean its present composition. Not to be irksome, we may pass over an array of figures and a number of provisional assumptions, in order to reach conclusions of general interest. These conclusions are, that it would take, in round numbers, 20,000,000 years to accumulate the quantity of sulphates of lime and magnesia contained in the vast bulk of the ocean, but only 480,000 years to renew the carbonates of lime and magnesia; with reference, however, to the latter constituents, it must be borne in mind that a vast quantity of carbonate of lime is constantly being removed from sea-water for the supply of the hard parts of shell-fish, crustaceans, corals, and other marine animals, and consequently the amount calculated as present in the ocean is far from indicating the total quantity which is poured into it. But what are we to say of the chlorides, especially the chloride of sodium, which is the prime constituent of sea-water? The ocean contains so much of this salt, and the rivers usually so little, that we are driven to conclude from the author's calculations that it would take 200,000,000 years to renew the chlorides in the ocean!

Geological Changes in Colorado.—It is noted as an interesting fact by Dr. A. C. Peale, in the *American Journal of Science*, that Colorado, which now possesses the highest mass of mountains in the United States, and whose mean elevation is higher than that of any other State or Territory, was also one of the highest areas of the North American Continent in Palæozoic time. In very early time in Colorado there was archæan land rising above the Palæozoic sea. As the Carboniferous age progressed, this land diminished by encroachment of the sea, due to subsidence of the land. This subsidence continued through Triassic, Jurassic, and Cretaceous time, into the early Tertiary. At the close of the Lignitic there was a physical break, followed by a subsidence (at least locally) and subsequently by elevation, after the deposition of the Miocene strata. The elevation of the Rocky Mountains, as we now see them in Colorado, is the result of an elevation commencing in early Tertiary time and continuing through the period, accelerated perhaps at the close of the Lignitic, and the deposition of at least Lower Miocene strata. This elevation is probably still going on.

The Building System of Philadelphia.—A paper on "A Building System for Great Cities," published in the *Penn Monthly*, contains an account of what may be called the Philadelphia system, of separate houses for families of very moderate means—artisans, and even laborers. There are three primary forms of houses, viz., the two-story four-roomed house, the two-story six-roomed house, and the three-story eight-roomed house, the value of which is respectively $1,200 to $2,500, $2,500 to $3,800, and $3,000 to $5,000. They are always of brick, erected on stone-walled cellars not less than seven feet deep, fourteen by twenty-eight feet for the smallest houses, fourteen to sixteen by forty-two to forty-five feet for the six-roomed and the eight-roomed houses. All these are built in contiguous rows or blocks with a common wall between them. Since the inauguration of the system, which scarcely dates before the year 1862, building has made rapid progress. In 1867 it began to be specially active, and since that time an average of 4,500 houses yearly has been erected, of which 2,500 were two-story and 2,000 three-story. The writer of the paper in the *Penn Monthly* has learned, from a personal inspection of a district near the southern border of the city of Philadelphia, that three-fourths of the dwellings that have been erected two years or more are owned by those who live in them. In a space less than a mile square, and containing 4,000 dwellings, the proportion of vacant houses was less than two per cent. Certainly more than one-half of these dwellings were owned by their occupants, and often entire blocks of thirty or forty houses would show over ninety per cent. so owned.

Are the Salts of Copper poisonous?—Dr. Burcq, M. Galippe, and others, having in communications addressed to the Paris Academy of Sciences asserted that copper is not poisonous after the manner of lead, and that it may be absorbed for a long time without injurious consequences, Dr. E. Decaisne has submitted to the same Academy the results of observations made by himself, from which it would appear that the reverse is the fact. We present a synopsis of Dr. Decaisne's paper, which we find in *La Nature*. He states that in 1864 he published a memoir entitled "A Medical Study on Absinthe-Drinkers," in which it was shown that a great many of the cheaper qualities of absinthe contain sulphate of copper, and that, of a hundred and fifty absinthe-drinkers observed by him, a certain number gave clear evidence of copper-poisoning. Fifteen samples of absinthe, purchased at wine-shops in Paris, all contained sulphate of copper in varying proportions: three of the samples contained it in the proportion of twenty-five centigrammes to the litre. Indeed, some of the distillers frankly admitted that they used sulphate of copper to color the absinthe. M. Decaisne cited a recent case of poisoning by acetate of copper, that of a young man of twenty-three, who showed all the symptoms of acute poisoning by copper salts, after having drunk some "eau de vie de marc," an inferior quality of brandy. Analysis of a sample of this brandy showed it to contain 1.164 gramme of acetate of copper to the litre. The liquor had been distilled in an apparatus that had lain unused for a year, and which had become filled with acetate of copper. French statistics show that sulphate and acetate of lead rank third among substances employed in criminal poisoning.

NOTES.

Mr. Jabez Hogg, the eminent English microscopist, in a recent paper calls attention to certain "errors of interpretation" to which microscopists are liable in examining the scales of insects and other minute objects. Some such "errors of interpretation" were pointed out by Mr. John Michels in the Monthly two years ago, but his statements were at the time called in question by microscopists in various portions of this country. Mr. Hogg himself, when these errors were first pointed out in the London Microscopical Society by Dr. Piggott, expressed the opinion that the latter was laboring under a mistake. Later, however, he was convinced of the correctness of Piggott's views, and now confirms them with his own observations.

A pressure of forty to one hundred and twenty atmospheres has been found by Quincke to be incapable of forcing a perceptible quantity of carbonic-acid or hydrogen gas through a glass wall 1.5 millimetre in thickness, during a period of fifteen years.

A monument to Liebig was unveiled at Darmstadt, his native town, on May 12th, the seventy-fourth anniversary of his birth.

Died, in Berlin, on March 29th, Alexander Braun, Professor of Botany in the University of Berlin, aged seventy-two years. In a brief notice of his life Professor Asa Gray says: "His influence as a teacher is said to have been great; as an investigator, he stood in the first rank among the botanists of our time; as a man, his simple, earnest, and transparently truthful character won the admiration and love of all who knew him." With Braun's memoirs on the "Arrangement of the Scales of Pine-Cones, etc." (1830), began the present knowledge of phyllotaxis. Other noteworthy memoirs by this author are that on "Rejuvenescence in Nature," and "The Vegetable Individual in its Relation to Species," both of which have been translated into English.

The residual charcoal, after lixiviation of destructively distilled sea-weed, possesses an extraordinary power of absorption and deodorization. According to Mr. E. C. C. Stanford, its composition is about midway between that from wood and that from bone, in the proportion of carbon; but it is more nearly like the latter, from which it differs in containing more carbon and carbonates of calcium and magnesium, and less phosphates. It can be obtained at one-fourth the price of any other charcoal.

Mention is made, in *Land and Water*, of a singular hybrid, the progeny of a barnyard cock and a common duck. The body of the hybrid is like that of a duck, but the feet, which have three front claws and a rudimentary back one, are not webbed, and the upper mandible is that of a fowl, extending only half the length of the lower, which is that of a duck, the singular formation causing great difficulty in feeding.

A writer in the *American Naturalist* cites the following instance of carnivorous habits in the red-headed woodpecker: In the summer of 1876 a man in Humboldt County, Iowa, raised a large number of black

Cayuga ducks. While the birds were still very young, many of them disappeared, and the bodies of several were found with the brains picked out. On watching carefully, a red-headed woodpecker was caught in the act. He killed the tender duckling with a single blow on the head, and then picked out and ate the brains.

The "Transactions" of the American Society of Civil Engineers for May contains an article on "Approximate Determination of Stresses in the Eye-Bar Head," by W. H. Burr; minutes of meetings; an interesting letter written by General Philip Schuyler in 1799, giving his opinion of a plan proposed by Dr. Brown for supplying this city with water from the Bronx River; and a list of new books on engineering and technology, besides other matters of interest to engineers.

Mr. McNab, of the Edinburgh Botanical Society, states that the past spring in Scotland was more backward than any other during the last twenty-eight years.

Having measured the red blood-corpuscles of men belonging to fourteen different races or nationalities, Dr. Richardson, of Philadelphia, found the average diameter to be $\frac{1}{3224}$ of an inch, the maximum diameter being $\frac{1}{2777}$, and the minimum $\frac{1}{4000}$.

The "hard glass" manufactured by Siemens, of Dresden, by means of hydraulic pressure, is said to be stronger than Bastie's glass, in the proportion of five to three. Its fracture, according to the *English Mechanic*, is fibrous, not crystalline. Besides being stronger, it is also cheaper than Bastie's "tempered" glass; and, unlike the latter, sheets of the Dresden glass can be cut to any size with the diamond.

The number of blind persons per 100,000 of the population of Bavaria is 52; of the United States, 52; Prussia, 58; Belgium, 66; Switzerland, 77; Sweden, 81; France, 84; Norway, 184. The number of insane, cretins, and idiots, is, in Bavaria, 110 per 100,000; in the United States, 160; Scotland, 185; France, 238; Switzerland, 300; Würtemberg, 312; Norway, 340. Of deaf-mutes the United States have 45 per 100,000; Belgium, 46; Bavaria, 58; France, 58; Saxony, 60; Switzerland, 245.

Trade, commerce, is usually considered one of the chief influences favoring civilization; yet, according to Mr. James Irvine, it has the contrary effect in Africa. Every native is a trader from the day of his birth, and the cultivation of the soil is utterly neglected. The buying and selling of palm-oil, palm-kernels, and a few minor products, give them really all they require, and they cannot be stimulated to further exertion.

Langeroy, in a communication to the Paris Academy of Sciences, calls attention to the antiseptic properties of bichromate of potassa. According to him, one per cent. of the bichromate in water absolutely prevents putrefaction in all animal and vegetable substances. After meat has stood in the solution for a few months it resembles gutta-percha, and medals have been struck from it; but it becomes poisonous, and even dogs refuse to eat it. This antiseptic will doubtless be of great use for the preservation of natural-history specimens.

A simple and ingenious contrivance for drawing liquids from carboys is described in *La Nature*. It consists of two tubes passing into the carboy through the stopper, one of the tubes serving as a siphon, and the other as a means of increasing the air-pressure over the liquid. At its outer extremity the siphon has attached to it a short section of rubber or gutta-percha tube, which may be compressed by a clamp. To fill the siphon, a person blows through the short tube, with the clamp relaxed. When sufficient liquid is drawn off, the clamp is allowed to compress the walls of the elastic tube, stopping the flow.

In a late report on the origin of the skin-disease known as Delhi boil, or, as it has been lately named from its wide distribution in the East, Oriental sore, Drs. Lewis and Cunningham reject the view that the affection is attributable to parasitic agency. From extended observations in widely-separated districts they are led to ascribe the disease to the use of well-waters that contain a large quantity of salts, and are extremely hard. In Egypt, Asia Minor, and Syria, where the sore prevails, the well-waters are notoriously brackish, agreeing in this with many stations in India, where the disease is also prevalent.

Dr. C. A. Bressa, deceased in 1835, bequeathed all his property to the Turin Academy of Sciences, the net interest to be given every two years as a prize for the best work done, during the previous four years, in physics, natural history, chemistry, physiology, pathology, geology, history, geography, or statistics. The fund is now available, and the first award will be made two years hence. The competition will be open to the whole world, and the prize will amount to about $2,500.

Moles render to the farmer and gardener very considerable service at little or no cost—the damage they do being more than compensated by the destruction of worms and grubs. When they have eaten all the grubs and worms in a certain place, they emigrate to another, and there repeat their gratuitous work.

SIMON NEWCOMB.

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DOMESTIC RETROSPECT AND PROSPECT.[1]

By HERBERT SPENCER.

INDUCTION has greatly predominated over deduction throughout the foregoing chapters; and readers who have borne in mind that Part II. closes with a proposal to interpret social phenomena deductively, may infer either that this intention has been lost sight of, or that it has proved impracticable to deal with the facts of domestic life otherwise than by empirical generalization. On gathering together the threads of the argument, however, we shall find that the chief conclusions forced on us by the evidence are those which Evolution implies.

We have first the fact that, little as it might have been expected, the genesis of the family fulfills the law of Evolution under its leading aspects. In the rudest social groups nothing to be called marriage exists: the unions of the sexes are extremely incoherent. Family groups, consisting of mothers and such few children as can be reared without permanent paternal assistance, are necessarily small and soon dissolve: integration is slight. Within each group the relationships are less definite; since the children are mostly half-brothers or half-sisters, and the paternity is often uncertain. From such primitive families, thus small, incoherent, and indefinite, there arise, in conformity with the law of Evolution, divergent and redivergent types of families—some characterized by a mixed polyandry and polygyny; some that are polyandrous, differentiating into the fraternal and non-fraternal; some that are polygynous, differentiating into those composed of wives and those composed of a legitimate wife and concubines; some that are monogamous, among which, besides the ordinary form, there is the aberrant form distinguished by a wife

[1] Conclusion to the chapters on "The Domestic Relations," which complete vol. i. of the "Principles of Sociology."

married only for a part of each week. Of these genera and species of families, those varieties which are found in advanced societies are the most coherent, most definite, most complex. Not to dwell on intermediate types, we see, on contrasting with the primitive kind of family group that highest kind of family group which civilized peoples present, how relatively high is its degree of evolution. The marital relation has become perfectly definite; it has become extremely coherent—commonly lasting for life; in its initial form of parents and children it has grown larger—the number of children reared by savages being comparatively small; in its derived form, comprehending grandchildren, great-grandchildren, etc., all so connected as to form a definable cluster, it has grown relatively large; and this large cluster consists of members whose relationships are very heterogeneous.

Again, the developing human family fulfills, in increasing degrees, those traits which we saw at the outset are traits of the successively-higher forms of reproductive arrangements throughout the animal kingdom. Maintenance of species being the end to which maintenance of individual lives is necessarily subordinated, we find, as we ascend in the scale of being, a diminishing sacrifice of individual lives in the achievement of this end; and, as we ascend through the successive grades of societies with their successive grades of family, we find a further progress in the same direction. Human races of the lower types, as compared with those of the higher, show us a greater sacrifice of the adult individual to the species; alike in the brevity of that stage which precedes reproduction, in the relatively heavy tax entailed by the rearing of children under the conditions of savage life, and in the abridgment of the period that follows: women especially, early bearing children and exhausted by the toils of maternity, having a premature old age soon cut short. In superior family types there is also less sacrifice of juvenile life: infanticide, which in the poverty-stricken groups of primitive men is dictated by the necessities of social self-preservation, becomes rarer; and juvenile mortality otherwise caused decreases at the same time. Further, along with the diminishing sacrifice of adult life, there goes an increasing compensation for the sacrifice that has to be made: more prolonged and higher pleasures are taken in rearing progeny. Instead of states in which children are early left to provide for themselves, or in which, as among Bushmen, fathers and sons quarreling try to kill one another, or in which, as Burton says of the East Africans, "when childhood is past, the father and son become natural enemies, after the manner of wild beasts," there comes a state in which keen interest in the welfare of children extends throughout parental life. And then to this pleasurable care of offspring, increasing in duration as the family develops, has to be added an entirely new factor—the reciprocal pleasurable care of parents by offspring: a factor which,

feeble where the family is rudimentary and gaining strength as the family develops, serves in another way to lessen the sacrifice of the individual to the maintenance of the species, and begins, contrariwise, to make the maintenance of the species conduce to the more prolonged life, as well as to the higher life, of the individual.

A fact not yet named remains. Evolution of the higher types of family, like evolution of the higher types of society, has gone hand-in-hand with evolution of human intelligence and feeling. The general truth that there exists a necessary connection between the nature of the social unit and the nature of the social aggregate, and that each continually moulds and is moulded by the other, is a truth which holds of domestic organization as well as of political organization. The ideas and sentiments which make possible any more advanced phase of associated life, whether in the family or in the state, imply a preceding phase by the experiences and discipline of which they were acquired; and these, again, a next preceding phase; and so from the beginning. On turning to the last part of the "Principles of Psychology" (edition of 1872), containing chapters on "Development of Conceptions," "Sociality and Sympathy," "Ego-Altruistic Sentiments," "Altruistic Sentiments," the reader will find it shown how the higher forms alike of intellect and feeling, made possible only by the social environment, evolve as this environment evolves—each increment of advance in the one being followed by an increment of advance in the other. And carrying out this doctrine he will see that since altruism plays an important part in developed family life, the higher domestic relations have become possible only as the adaptation of man to the social state has progressed.[1]

In considering deductively the connections between the forms of domestic life and the forms of social life, and in showing how these are in each type of society related to one another because jointly related to the same type of individual character, it will be convenient to deal simultaneously with the marital arrangement, the family structure, the *status* of women, and the *status* of children.

Primitive life, cultivating antagonism to prey and enemies, brute or human—daily yielding the egoistic satisfaction of conquest over alien beings which prove to be weaker, daily gaining pleasure from acts which entail pain—maintains a type of nature which generates coercive rule, social and domestic. Brute strength glorying in the predominance which brings honor, and unchecked by regard for others' welfare, seizes whatever women fancy prompts, adding to them and changing them at will. And children, at the mercy of this utter self-

[1] As included in the general theory of the adaptation of organic beings to their circumstances, this doctrine that the human mind, especially in its moral traits, is moulded by the social state, pervades *social statics;* and is especially insisted upon in the chapter entitled "General Considerations."

ishness, are preserved only when and as far as the instinct of parenthood predominates. Clearly, then, weakness of the marital relation, indefinite incoherent forms of family, harsh treatment of women, and infanticide, are inevitable concomitants of militancy in its extreme form.

The advance from these lowest social groups, hardly to be called societies, to groups that are larger, or have more structure, or both, implies increased coöperation. This coöperation may be compulsory or voluntary, or it may be, and usually is, partly the one and partly the other. We have seen that great militancy implies predominance of compulsory coöperation, and that great industrialness implies predominance of voluntary coöperation. Here we have to observe that it is deductively manifest, as we have found it inductively true, that the accompanying domestic relations are in each case congruous with the necessitated social relations.

The individual nature which exercises that despotic control and submits to that extreme subjection implied by pronounced militancy in developing societies, no less than the fostering of egoism and repression of sympathy by a life devoted to war, inevitably determines the arrangements within the household as it does the arrangements without it. Hence the disregard of women's claims shown in stealing and buying them; hence the inequality of *status* between the sexes entailed by polygyny; hence the use of women as laboring slaves; hence the life and death power over wife and child; and hence that constitution of the family which subjects all its members to the eldest male.

Conversely, the type of individual nature developed by voluntary coöperation in societies that are predominantly industrial, whether they be peaceful, simple tribes, or nations that have in great measure outgrown militancy, is a relatively-altruistic nature. The daily habit of exchanging services, or giving products representing work done for money representing work done, is a habit of seeking such egoistic satisfaction as allows like egoistic satisfactions to those dealt with. There is an enforced respect for others' claims; there is an accompanying mental representation of their claims implying, in so far, fellow-feeling; and there is an absence of those repressions of fellow-feeling involved by coercion. Necessarily, the type of character thus cultivated, while it modifies social actions and arrangements, modifies also domestic actions and arrangements. The discipline which brings greater recognition of the claims of fellow-men brings greater recognition of the claims of women and children. The practice of consulting the wills of those with whom there is coöperation outside the household, brings with it the practice of consulting the wills of those with whom there is coöperation inside the household. The marital relation becomes changed from one of master and subject into one of approximately-equal partnership; while the bond becomes

less that of legal authority and more that of affection. The parental and filial relation ceases to be a tyranny which sacrifices child to parent, and becomes one in which, rather, the will of the parent subordinates itself to the welfare of the child.

Thus the results deducible from the natures of militancy and industrialness correspond with those which we have found are, as a matter of fact, exhibited. And, as implying the directness of the alleged connections, I may here add an instance showing that in the same society the domestic relations in the militant part retain the militant character, while the domestic relations in the industrial part are beginning to assume the industrial character. Commenting on the laws of inheritance in ancient France, as affecting children of different sexes and different ages, Königswarter remarks that "it is always the feudal and noble families which cling to the principle of inequality, while the ideas of equality penetrate everywhere into the *roturières* and *bourgeoises* families." Similarly Thierry, speaking of a new law of the thirteenth century, equalizing rights of property between the sexes and among children, says: "This law of the *bourgeoisie*, opposed to that of the nobles, was distinguished from it by its very essence. It had for its basis natural equity."

And now we come to the interesting question, "What may be inferred respecting the future of the domestic relations?" We have seen how the law of evolution in general has been thus far fulfilled in the genesis of the family. We have also seen how, during civilization, there has been carried still further that conciliation of the interests of the species, of the parents, and of the offspring, which has been going on throughout organic evolution at large. Further, we have noted that these higher traits in the relations of the sexes to one another and to children, which have accompanied social evolution, have been made possible by those higher traits of intelligence and feeling produced by the experiences and disciplines of progressing social states. And we have, lastly, observed the connections between special traits so acquired and special types of social structure and activity. Assuming, then, that evolution will continue along the same lines, let us consider what further changes may be anticipated.

It is first inferable that, throughout times to come, the domestic relations of different peoples inhabiting different parts of the earth will continue to be unlike. We must beware of supposing that developed societies will become universal. As with organic evolution, so with super-organic evolution, the production of higher forms does not involve extinction of all lower forms. As superior species of animals, while displacing certain inferior species that compete with them, leave many other inferior species in possession of inferior habitats, so the superior types of societies, while displacing those inferior types occupying localities they can utilize, will not displace inferior

types inhabiting barren or inclement localities. Civilized peoples are unlikely to expel the Esquimaux. The Fuegians will probably survive, because their island cannot support a civilized population. It is questionable whether the groups of wandering Semites who have for these thousands of years occupied Eastern deserts will be extruded by societies of higher kinds. And perhaps many steaming malarious regions in the tropics will remain unavailable by races capable of much culture. Hence the domestic, as well as the social, relations proper to the lower varieties of man are not likely to become extinct. Polyandry may survive in Thibet; polygyny may prevail throughout the future in parts of Africa; and, among the remotest groups of hyperboreans, mixed and irregular relations of the sexes will probably continue.

It is possible, too, that in certain regions militancy may persist, and that along with the political relations natural to it there may survive the domestic relations natural to it. Wide tracts, such as those of Northeastern Asia, unable to support populations dense enough to form industrial societies of advanced types, will perhaps remain the habitats of societies having those imperfect forms of state and family which go along with offensive and defensive activities.

Omitting such surviving inferior types, we may here limit ourselves to types carrying further the evolution which civilized nations now show us. Assuming that among these industrialism will increase and militancy decrease, we have to ask what are the domestic relations likely to coexist with complete industrialism.

The monogamic form of the sexual relation is manifestly the ultimate form; and any changes to be anticipated must be in the direction of completion and extension of it. By observing what possibilities there are of greater divergence from the arrangements and habits of the past, we shall see what modifications are probable.

Many acts that are normal with the uncivilized are, with the civilized, transgressions and crimes. Promiscuity, once unchecked, has been more and more reprobated as societies have progressed; abduction of women, originally honorable, is now criminal; the marrying of two or more wives, allowable and creditable in inferior societies, has become in superior societies felonious. Hence, future evolution, along lines thus far followed, may be expected to extend the monogamic relation by extinguishing promiscuity, and by suppressing such crimes as bigamy and adultery. Dying out of the mercantile element in marriage may also be inferred. After wife-stealing came wife-purchase; and then followed the usages which made, and continue to make, considerations of property predominate over considerations of personal preference. Clearly, wife-purchase and husband-purchase (which exists in some semi-civilized societies), though they have lost their original gross forms, persist in disguised forms. Already some

disapproval of those who marry for money or position is expressed; and this, growing stronger, may be expected to purify the monogamic union by making it in all cases real instead of being in some cases nominal.

As monogamy is likely to be raised in character by a ublic sentiment requiring that the legal bond shall not be entered into unless it represents the natural bond, so, perhaps, it may be that maintenance of the legal bond will come to be held improper if the natural bond ceases. Already increased facilities for obtaining divorce point to the probability that, whereas, in those early stages during which permanent monogamy was being evolved, the union by law (originally the act of purchase) was regarded as the essential part of marriage, and the union by affection as non-essential, and whereas at present the union by law is thought the more important and the union by affection the less important, there will come a time when the union by affection will be held of primary moment and the union by law as of secondary moment: whence reprobation of marital relations in which the union by affection has dissolved. That this conclusion will seem unacceptable to most is probable—I may say, certain. In passing judgment on any modified arrangement suggested as likely to arise hereafter, nearly all err by considering what would be likely to result from the supposed change, all other things remaining unchanged. But other things must be assumed to have changed *pari passu.* Those higher sentiments accompanying union of the sexes, which do not exist among primitive men, and were less developed in early European times than now (as is shown in the contrast between ancient and modern literatures), may be expected to develop still more as decline of militancy and increase of industrialness foster altruism; for sympathy, which is the root of altruism, is a chief element in these sentiments. Moreover, with an increase of altruism must go a decrease of domestic dissension. Whence, simultaneously, a strengthening of the moral bond and a weakening of the forces tending to destroy it. So that the changes which may further facilitate divorce under certain conditions are changes which will make those conditions more and more rare.

There may, too, be anticipated a strengthening of that ancillary bond constituted by joint interest in children. In all societies this is an important factor, and has sometimes great effect among even rude peoples. Falkner remarks that although the Patagonian marriages "are at will, yet when once the parties are agreed, and have children, they seldom forsake each other, even in extreme old age." And this factor must become more efficient in proportion as the solicitude for children becomes greater and more prolonged, as we have seen that it does with progressing civilization, and must continue to do.

But leaving open the question what modifications of monogamy, conducing to increase of real cohesion rather than nominal cohesion,

are likely to arise, there is one conclusion we may draw with certainty. Recurring to the three ends to be subserved in the order of their importance—welfare of species, welfare of offspring, welfare of parents—and seeing that, in the stages now reached by civilized peoples, welfare of species is effectually secured in so far as maintenance of numbers is concerned, the implication is that welfare of offspring must hereafter determine the course of domestic evolution. Societies which from generation to generation produce in due abundance individuals who, relatively to the requirements, are the best physically, morally, and intellectually, must become the predominant societies, and must tend through the quiet process of industrial competition to replace other societies. Consequently, marital relations which favor this result in the greatest degree must spread, while the prevailing sentiments and ideas must become so moulded into harmony with them that other relations will be condemned as immoral.

If, still guiding ourselves by observing the course of past evolution, we ask what changes in the *status* of women may be anticipated, the answer must be that a further approach toward equality of position between the sexes will take place. With decline of militancy and rise of industrialness—with decrease of compulsory coöperation and increase of voluntary coöperation—with strengthening sense of personal rights and accompanying sympathetic regard for the personal rights of others, must go a diminution of the political and domestic disabilities of women, until there remain such only as differences of constitution entail.

To draw inferences more specific is somewhat hazardous: probabilities and possibilities only can be indicated. While in some directions the emancipation of women has to be carried further, we may suspect that in other directions their claims have already been pushed beyond the normal limits. If from that stage of primitive degradation in which they were habitually stolen, bought and sold, made beasts of burden, inherited as property, and killed at will, we pass to the stage America shows us, in which a lady wanting a seat stares at a gentleman occupying one until he surrenders it, and then takes it without thanking him, we may infer that the rhythm traceable throughout all changes has carried this to an extreme from which there will be a recoil. The like may be said of some other cases: what were originally concessions have come to be claimed as rights, and, in gaining the character of assumed rights, have lost much of the grace they had as concessions. Doubtless, however, there will remain in the social relations of men and women, not only observances of a kind called forth by sympathy of the strong for the weak irrespective of sex, and still more called forth by sympathy of the stronger sex for the weaker sex, but also observances which originate in the wish, not consciously formulated but felt, to compensate women for certain

disadvantages entailed by their constitutions, and so to equalize the lives of the sexes as far as possible.

In respect of domestic power, the relative position of women will doubtless rise; but it seems improbable that absolute equality with men will be reached. Legal decisions from time to time demanded by marital differences, involving the question which shall yield, are not likely to reverse all past decisions. Evenly though law may balance claims, it will, as the least evil, continue to give, in case of need, supremacy to the husband, as being the more judicially-minded. And, similarly, in the moral relations of married life, the preponderance of power, resulting from greater massiveness of nature, must, however unobtrusive it may become, continue with the man.

When we remember that up from the lowest savagery civilization has, among other results, brought about an increasing exemption of women from bread-winning labor, and that in the highest societies they have become most restricted to domestic duties and the rearing of children, we may be struck by the anomaly that at the present time restriction to indoor occupations has come to be regarded as a grievance, and a claim is made to free competition with men in all out-door occupations. This anomaly is traceable in part to the abnormal excess of women; and obviously a state of things which excludes many women from those natural careers in which they are dependent on men for subsistence justifies the demand for freedom to pursue independent careers. That any hinderances standing in their way should be, and will be, abolished must be admitted. At the same time it must be contended that no considerable alteration in the careers of women in general can be, or should be, so produced; and, further, that any extensive change in the education of women, made with the view of fitting them for businesses and professions, would be mischievous. If women comprehended all that is contained in the domestic sphere, they would ask no other. If they could see all that is implied in the right education of children, to a full conception of which no man has yet risen, much less any woman, they would seek no higher function.

That in time to come the political *status* of women may also be raised to something like equality with that of men, seems a deduction naturally accompanying the preceding ones. But such an approximate equalization, normally accompanying a social structure of the completely industrial type, is not a normal accompaniment of social types still partially militant. Just noting that the giving to men and women equal amounts of political power, while the political responsibilities entailed by war fell upon men only, would involve a serious inequality, and that the desired equality is therefore impracticable while wars continue, it may be contended that though the possession of political power by women would possibly improve a society in which state-regulation had been brought within the limits proper to

pure industrialism, it would injure a society in which state-regulation has the wider range characterizing a more or less militant type. Several influences would conduce to retrogression. The greater respect for authority and weaker sentiment of individual freedom characterizing the feminine nature would tend toward the maintenance and multiplication of restraints. Ability to appreciate special and immediate results, joined with inability to appreciate general and remote results, characterizing the majority of men, and still more characterizing women, would, if women had power, entail increase of coercive measures for achieving present good, at the cost of future evil caused by excess of control. But there is a more direct reason for anticipating mischief from the exercise of political power by women, while the industrial form of political regulation is incomplete. We have seen that the welfare of a society requires that the ethics of the family and the ethics of the state shall be kept distinct. Under the one the greatest benefits must be given where the merits are the smallest; under the other the benefits must be proportioned to the merits: for the infant, unqualified generosity; for the adult citizen, absolute justice. The ethics of the family have for their correlatives the parental instincts and sentiments, which, in the female, are qualified in a smaller degree by other feelings than in the male. Already these emotions proper to parenthood, as they exist in men, lead them to carry the ethics of the family into the policy of the state; and the mischief resulting would be increased were these emotions, as existing in women, directly to influence that policy. The progress toward justice in social arrangements would be retarded, and demerit would be fostered at the expense of merit still more than now.

But, in proportion as the conceptions of pure equity become clearer; as fast as the *régime* of voluntary coöperation develops to the full the sentiment of personal freedom, with a correlative regard for the like freedom of others; as fast as there is approached a state under which no restrictions upon individual liberty will be tolerated, save those which the equal liberties of fellow-citizens entail; as fast as industrialism evolves its appropriate political agency, which, while commissioned to maintain equitable relations among citizens, is shorn of all those powers of further regulation proper to the militant type; so fast may the extension of political power to women go on without evil. The moral evolution which leads to concession of it will be the same moral evolution which renders it harmless and probably beneficial.

No very specific conclusions are to be drawn respecting future changes in the *status* of children. Parental and filial relations, less regulated in detail by law and custom than all others, have more readily changed under the influence of changed sentiments and ideas, and, while becoming generally liberalized, have become so far varied that it is difficult to characterize them.

While an average increase of juvenile freedom is to be anticipated, there is reason to think that here and there it has already gone too far. I refer to the United States. Besides in some cases unduly subordinating the lives of adults, the degree of independence there allowed to the young appears to have the effect of bringing them forward prematurely, initiating them too early in the excitements proper to maturity, and so tending to exhaust the interests of life before it is half spent. Such regulation of childhood as conduces to full utilization of childish activities and pleasures, before the activities and pleasures of manhood and womanhood are entered upon, is better for offspring at the same time that it is better for parents.

How far is parental authority to go? and at what point shall political authority check it? are questions to be answered in no satisfactory way. Already I have given reasons for thinking that the powers and functions of parents have been too far assumed by the state; and that probably a reintegration of the family will follow its present undue disintegration. It seems possible that from the early form in which social and family organizations are compulsory in character, we are passing through semi-militant, semi-industrial phases, in which the organizations of both state and family are partly compulsory, partly voluntary, in character; and that, along with complete social reintegration on the basis of voluntary coöperation, will come domestic reintegration of allied kind, under which the life of the family will again become as distinct from the life of the state as it originally was. Still there remain the theoretical difficulties of deciding how far the powers of parents over children may be carried; to what extent disregard of parental responsibilities is to be tolerated; when does the child cease to be a unit of the family and become a unit of the state. Practically, however, these questions will need no solving; since the same changes of character which bring about the highest form of family will almost universally prevent the rise of difficulties which result from characters of lower types proper to lower societies.

Moreover, there always remains a security. Whatever conduces to the highest welfare of offspring must more and more establish itself through the replacing of children of inferior parents reared in inferior ways by children of better parents reared in better ways. As lower creatures at large have been preserved and advanced through the instrumentality of parental instincts; and as in the course of human evolution the domestic relations originating from the need for prolonged care of offspring have been assuming higher forms; and as the care taken of offspring has been becoming greater and more enduring; we need not doubt that, in the future, along with the more altruistic nature accompanying a higher social type, there will come relations of parents and children needing no external control to insure their well-working.

One further possibility of domestic evolution remains. The last component to show itself among the feelings which hold the family together, the care of parents by offspring, is the one which has most room for increase. Absent in brutes, small among primitive men, considerable among the partially civilized, and tolerably strong among the best of those around us, filial affection is a feeling that admits of much further growth, which is needed to make the cycle of domestic life complete. At present, the latter days of the old whose married children live away from them are made dreary by the lack of those remaining pleasures to be derived from the constant society of descendants; but the time will come when this evil will be met by an attachment of adults to parents which, if not as strong as that of aged parents to children, approaches it in strength.

Further development in this direction will not, however, occur under social arrangements which partially absolve parents from the care of offspring. A stronger feeling to be displayed by child for parent in later life must be established by a closer intimacy between parent and child in early life. No such higher stage is to be reached by walking in the ways followed by the Chinese for these two thousand years. We shall not rise to it by imitating, even partially, the sanguinary Mexicans, whose children, at the age of four, or sometimes later, were delivered over to be educated by the priests. We shall not improve family feeling by approaching toward the arrangements of the Koossa-Caffres, among whom "all children above ten or eleven years old are publicly instructed under the inspection of the chief." This latest of the domestic affections will not be fostered by retrograding toward customs like those of the Andamanese, and, as early as possible, changing the child of the family into the child of the tribe. Contrariwise, such a progress will be achieved only in proportion as both moral and intellectual culture are carried on by parents to an extent now rarely attempted. When the unfolding minds of children are no longer thwarted, and stunted, and deformed, by the mechanical lessons of stupid teachers—when instruction, instead of giving mutual pain, gives mutual pleasure by ministering in proper order to faculties which are severally eager to appropriate fit knowledge presented in fit forms—when, with a wide diffusion of adult culture, joined with rational ideas of teaching, there goes a spontaneous unfolding of the juvenile mind such as is even now occasionally indicated by exceptional facility of acquisition—when the earlier stages of education passed through in the domestic circle have become, as they will in ways scarcely dreamed of at present, daily aids to the strengthening of sympathy, intellectual and moral, leaving only the more special cultures to be carried on by others; then will the latter days of life be smoothed by a greater filial care, reciprocating the greater parental care bestowed in earlier life.

ODD FORMS AMONG FISHES.

By Professor SANBORN TENNEY.

PROBABLY there is no group of animals—certainly no group of vertebrates—that exhibits more strange and even monstrous forms than fishes.

The typical fish, we may well believe, is some such form as the salmon, or the cod, or the bass, or an average of these and their numerous allies. In a word, the ordinary fishes of the ocean, lakes, and streams, give us essentially the true idea of the typical fish.

But what remarkable departures from these ordinary forms do we

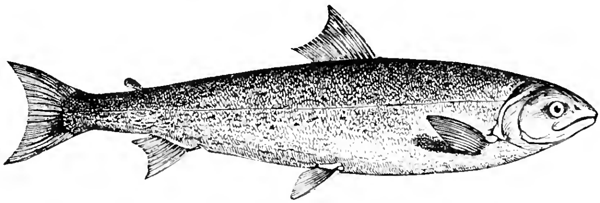


Fig. 1.—Salmon, introduced here as an example of a typical fish.

find when we take a survey of the whole vast group of animals that are called fishes!

Let us take the salmon as a fair sample of an ordinary fish, and then briefly notice a few of the strange forms to which the name is applied.

If we look at the rays (Fig. 2), we see "fishes" whose width is so great in proportion to their length, that in giving their dimensions it would seem to be quite the natural thing to put down the *width* as the prominent measurement instead of the length, as is our custom in the case of ordinary fishes. And it may be remarked here that the great relative breadth of these animals is connected with the kind of movements which they exhibit in progression. Instead of ordinary swimming, these animals effect locomotion by a sort of flight through the waters; and hence are often called "sea-eagles," "sea-vampires," etc. They all belong to the sea. Some of the rays are of wonderful dimensions, although the ordinary kinds are only about two or three feet wide. One was taken near Messina which weighed half a ton. One taken near Barbadoes is said to have been so large that it required seven yoke of oxen to draw it! Levaillant tells us of one which was thirty feet wide and twenty-five feet long; and Dekay states that one of these monsters of the deep has been known to seize the cable of a small vessel at anchor, and draw it several miles with great velocity!

The rays have the mouth, nostrils, and gill-openings, on the under-side. Like the sharks, they are without gill-covers, and have the gills fixed by both margins. Their teeth differ from those of all ordinary

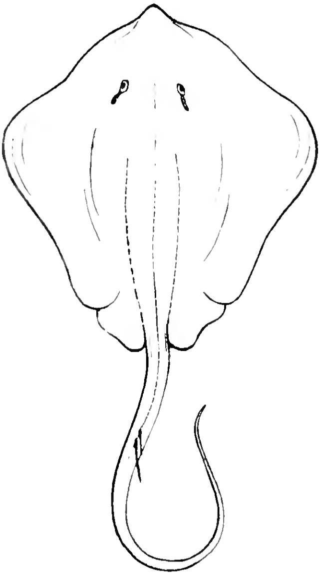


FIG. 2.—STING-RAY (*Trygon hastata*, Storer).

fishes, being of a definite form, bounded by planes symmetrically arranged, the whole forming a beautiful mosaic (Fig. 3).

Remarkable as are the form and general structure of the rays, as indicated above, a still more remarkable structure is exhibited in some

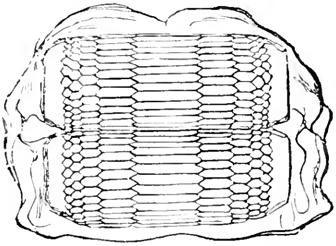


FIG. 3.—TEETH OF A RAY.

of them; for those known as torpedoes (Fig. 4) are so constructed that they are a powerful galvanic battery. These have the space between the pectoral fins, the head, and the gills, on each side, filled with membranous tubes which are divided by horizontal partitions into small cells filled with a sort of mucus and traversed by nerves;

and by means of this apparatus they give violent shocks to animals with which they come in contact.

Hardly less strange than the rays are those animal structures

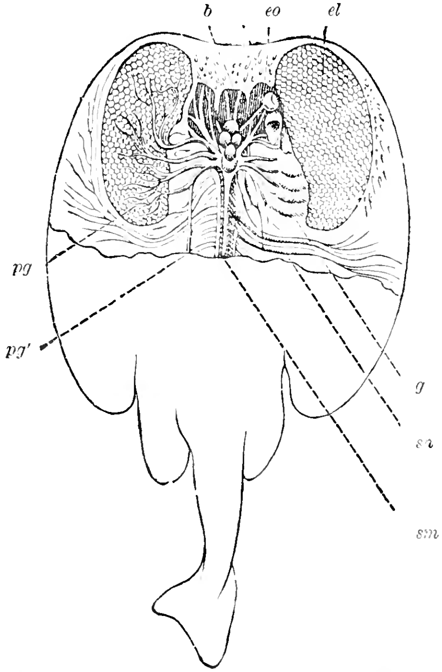


FIG. 4.—TORPEDO. *b*, brain; *eo*, eye and optic nerve; *el*, electric organs; *sn*, spinal nerves; *sm*, spinal marrow; *pg*, pneumogastric nerves going to the electric organs; *pg'*, branch of the preceding; *g*, gills.

which remind us somewhat of the rays on the one hand, and the sharks on the other, but which differ from both in several important respects, but especially in having a very long depressed and bony

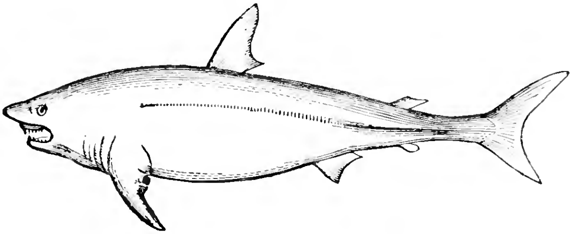


FIG. 5.—MACKEREL-SHARK (*Lamna punctata*, Storer).

snout, armed on each side with spines implanted like teeth, the whole constituting a most formidable weapon. These are the sawfishes (Fig. 7), which attain a length of fifteen feet or more.

Every one sees at a glance that the sharks (Figs. 5, 6, 7) are widely different from all ordinary fishes. Their peculiar outline in general, their unequal-lobed tail, their transverse mouth on the underside of the head, their formidable array of lancet-shaped teeth,

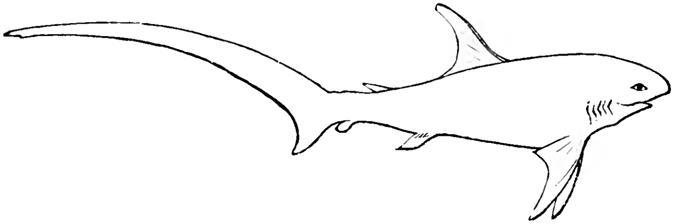


Fig. 6.—Thresher-Shark (*Alopias vulpes*, Bonaparte).

their fixed gills without gill-covers, their rough skin, their pillow-shaped eggs with long, tendril-like appendages at the corners (Fig. 8), all combine to separate them about as far as possible from typical fishes. And if we compare them with one another, what wonderfully-

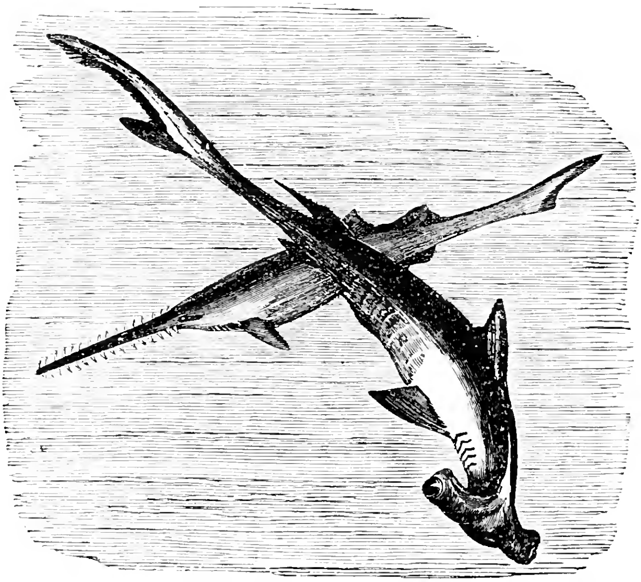


Fig. 7.—Hammer-head Shark (*Zygæna malleus*, Valenciennes); and Sawfish (*Pristis antiquorum*, Latham).

diversified forms do we see as we pass from the dog-sharks to the mackerel-sharks, and from the latter to the white sharks, and from these to the threshers, and to the hammer-heads, and so on through the whole list!

And who that has studied only the ordinary fishes would at length

expect to find such a fish as the chimæra (Fig. 9)—an animal whose general appearance, it is true, is somewhat shark-like, but which, if possible, is more strange and monstrous than any of the sharks or

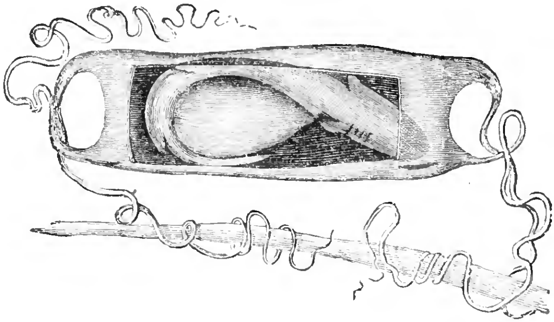


FIG. 8.—SHARK'S EGG, WITH A PORTION OF THE COVERING REMOVED.

rays? This curious arctic fish, which attains the length of four feet, is not only exceedingly remarkable in its general appearance, but it is especially remarkable in its structure—having no upper jaw, the four

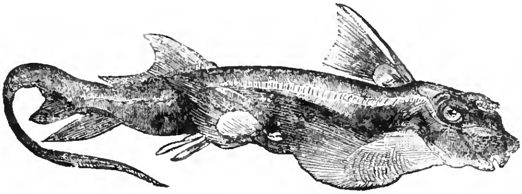


FIG. 9. NORTHERN CHIMÆRA, OR KING OF HERRINGS (*Chimæra monstrosa*).

upper teeth being supported on the front of the skull, and only two teeth in the lower jaw, and having no backbone, this important part being represented only by the most rudimentary structure, such as

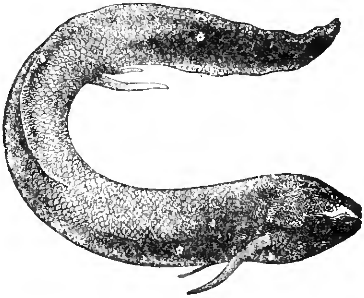


FIG. 10.—LEPIDOSIREN.

exists in the ordinary embryonic vertebrate, and which is known under the name of chorda dorsalis.

In the tropical regions of America and Africa there is found a strange "fish," about three feet long, and called the lepidosiren (Fig. 10)—scaly siren, as the name implies. In its general aspect it is decidedly reptilian, and some writers have described it under the reptiles. Nor is it strange that naturalists should have been in doubt in regard to its true affinities, for it is decidedly reptilian in appearance, and is so unlike the typical fishes in structure that it has both gills and lungs—thus leading a sort of double life. It is believed that in important respects this fish is like some of the fishes that lived in the old Devonian times.

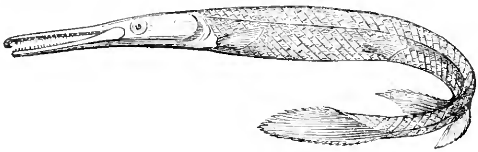


Fig. 11.—Gar-pike (*Lepidosteus*).

The gar-pikes, too, depart considerably from ordinary fishes, especially in their teeth, hard, shining scales, and heterocercal tail (Fig. 11).

And the sturgeons (Fig. 12), ballasted and protected with rows of large bony plates, and with a nose fitted for "rooting," and a mouth

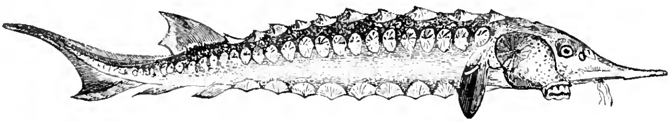


Fig. 12.—Sturgeon (*Acipenser oxyrhynchus*, Mitchell).

for sucking, and a tail more or less like that of a shark, are very unlike anything we should select as a typical fish.

And what shall we say of the "sea-horses," or hippocamps (Fig. 13), whose head reminds us far more of the head of a horse than it

Fig. 13.—Sea-Horse (*Hippocampus Hudsonius*, Dekay).

Fig. 14.—Pipe-fish (*Sygnathus Peckianus*, Storer).

does of that of a typical fish? And of the pipe-fishes (Fig. 14), or sygnathi, whose body is all length, nearly, and whose mouth is just at the extremity of a long snout; and which have this strange habit,

namely, that the males receive the eggs into a pouch, in which they carry them till they are hatched?

Who that has studied and heard of only ordinary fishes would ever expect to see such an animal as the sunfish (*Orthagoriscus*); and who, when he sees one for the first time, would regard it as anything short of a monstrosity? This huge fish (Fig. 15), weighing, in some

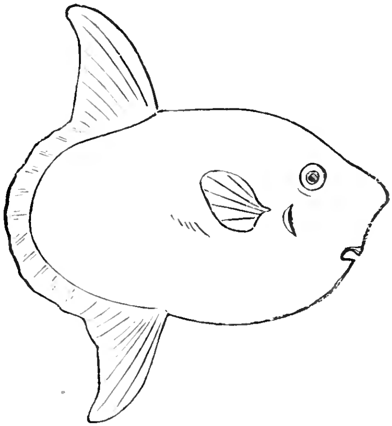


FIG. 15.—SUNFISH (*Orthagoriscus mola*, Schreiber).

cases, five hundred pounds, is so abbreviated behind, that it is scarcely represented behind the dorsal fin, making it one of the most remarkable forms, and one of the most difficult to explain, to be found in the whole class.

The trunk-fishes (Fig. 16) are very remarkable forms. They have an inflexible shield of bony plates, so that the mouth, tail, and fins, are the only movable parts. These small fishes—from three inches to

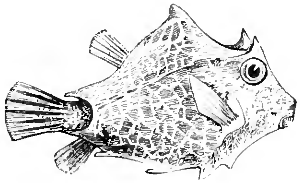


FIG. 16.—TRUNK-FISH (*Lactophrys Camelinus*, Dekay).

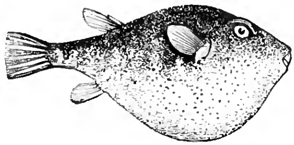


FIG. 17.—PUFFER (*Tetraodon turgidus*, Mitcheli).

a foot in length—are thus in strong contrast with the ordinary fishes, whose whole bodies are so flexible that there is the greatest freedom of motion throughout nearly the entire structure.

Again, the puffers (Fig. 17) are remarkable forms. Being more or less covered with spines, and having the habit of inflating themselves by swallowing air, thus giving them more or less of a rounded

appearance, they may perhaps not improperly be called the "sea-urchins" among fishes.

Another strange form is the fishing-frog, or angler (Fig. 18), whose enormous mouth enables it to swallow animals nearly as large as

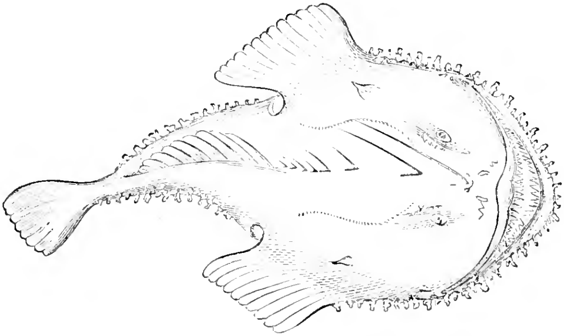


Fig. 18.—Angler, or Goose-fish (*Lophius Americanus*, Cuvier).

itself, and whose anterior dorsal rays bear fleshy filaments, which it is said to use as a bait to decoy other fishes, that it may secure them as food.

In the cavities under stones in the sea are found the little toad-fishes (Fig. 19), whose head is so like that of a toad that we are ready to concede that both the popular and scientific names of these animals (*batrachus*) are well bestowed.

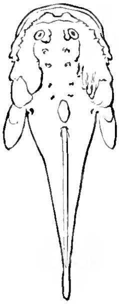


Fig. 19.—Toad-fish (*Batrachus tau*, Linnæus).

There are many other fishes that depart so much from the ordinary forms that the common fisherman instinctively names them after some land-animals. The sea-wolf or wolf-fish is one of these, although its head is more like that of a wild-cat or a lynx than it is like that of a wolf. It is sometimes called the sea-cat. Its body is long, with a dorsal fin nearly the whole length, and the head is round; its mouth is armed with a most formidable array of teeth, making this animal,

which is five or six feet long, a most dangerous antagonist when the fisherman comes in direct conflict with it.

The hand-fishes of the tropics are very small, but their grotesque appearance and hand-shaped fins, suited for creeping, make them very

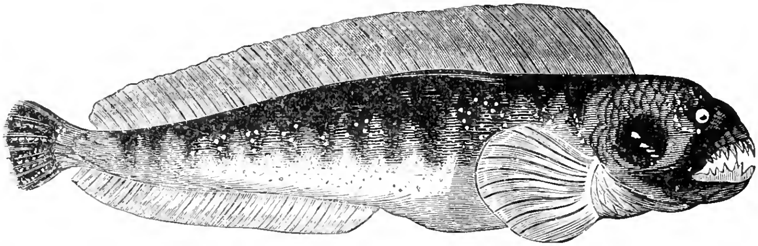


FIG. 20.—SEA-WOLF (*Anarrhichas lupus*).

proper subjects of notice in this connection. One very small species is found on our Atlantic coast.

Nor ought the lump-fish (Fig. 21) to be omitted in this enumeration; for, although it is not specially remarkable in its general aspect, it is very remarkable in at least one portion of its structure. It has

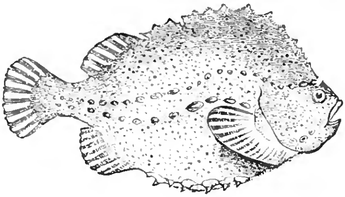


FIG. 21.—LUMP-FISH (*Cyclopterus lumpus*, Linnæus).

its ventral fins united so as to form a cup-shaped disk, and by means of this disk this fish is able to attach itself to any surface with great firmness. Pennant states that, upon putting one into a pailful of water, it adhered to the bottom so firmly that he lifted it by the fish's tail.

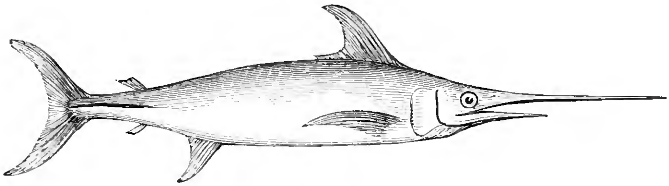


FIG. 22.—SWORD-FISH.

Nor ought we to omit to mention the sword-fish, although it exhibits nothing specially remarkable in its general form, excepting its sword-like prolongation of the jaw (Fig. 22). And on account of its

movable spine at the base of the tail we may merely mention the herbivorous lancet-fish, although in its general outline it is scarcely more remarkable than a perch or a bream.

"Sea-ravens" (*Hemipterus*, Fig. 23), "sea-robins" (*Prionotus*), "sea-swallows" (*Dactylopterus*), and sculpins (*Cottus*), may well be called strange fishes, for their forms are so marked and so strange that they at once arrest the attention of the commonest observer at the

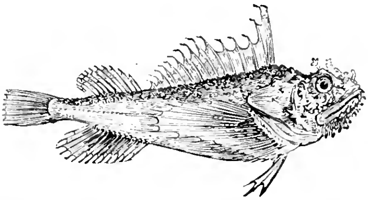


Fig. 23.—Sea-Raven (*Hemipterus Acadianus*, Storer).

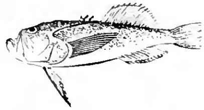


Fig. 24.—Star-Gazer (*Uranoscopus anoplos*, Cuvier).

sea-side. While all these have a certain general resemblance to one another, all agreeing in being remarkably ugly, each has its own marked peculiarities in the development of the head and fins, and in the curious fleshy filaments which are found upon some of them.

We may also justly include the little star-gazers (*Uranoscopus*, Fig. 24) of the Atlantic, whose eyes are so placed that they appear as if looking constantly toward the heavens, and whose mouth is cleft vertically, and has in it a long filament which can be protruded at will, and which is said to be used in attracting small fishes while the owner lies concealed in the mud.

Next we may mention the remora (Fig. 25), on whose head there is a sort of disk composed of laminæ which are serrated and movable, by means of which the fish can firmly attach itself to other animals.

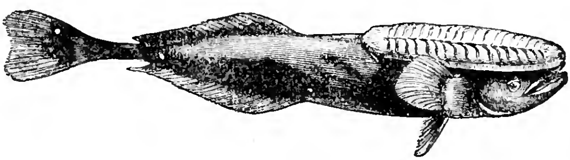


Fig. 25.—Remora (*Echeneis*).

It is said that it can be made useful by putting a ring attached to a line around its tail, and then allowing it to swim away in search of a victim; when it has firmly attached itself to a fish, both the remora and its captive are hauled in together.

Remarkable and strange as are all the forms of fishes which we have so far noticed, not one of them exhibits any want of bilateral symmetry. But we now come to a whole group of fishes, including

halibuts, turbots, soles, flounders (Fig. 26), etc., whose two sides are totally unlike—a peculiarity which is not only not found in any other

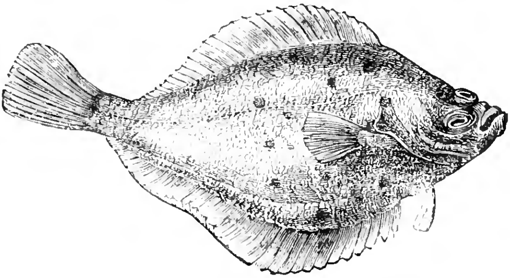


FIG. 26.—FLOUNDER (*Platessa vulgaris*, Cuvier).

group of fishes, but not in any other group of vertebrate animals. These strange fishes have the body flat, both eyes on the same side

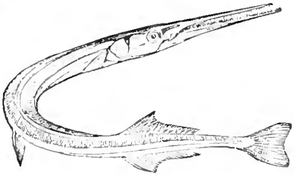


FIG. 27.—GAR-FISH (*Belone truncata*, LeSueur).

of the head, and the sides of the mouth unequal. They are without a swimming-bladder, live at the bottom of the sea, and are of all sizes,

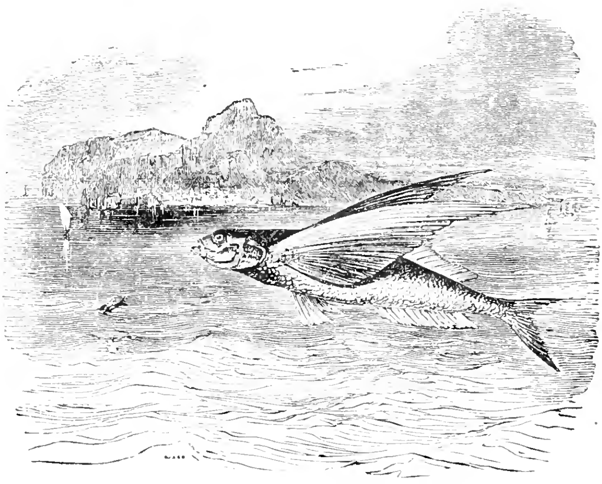


FIG. 28.—FLYING-FISH (*Exocœtus*).

from those not more than six or eight inches in length to those that attain a weight of six hundred pounds.

As for the gars, I should not mention them in this article, although they are quite peculiar in several respects, were it not for one fact connected with the nature of their skeleton. Their bones are of a green color, a peculiarity which, so far as I am informed, is unique among vertebrates.

Nor is there anything very peculiar about the flying-fishes, except the excessive development of their pectoral fins, and the habit of "flight" connected with this development (Fig. 28).

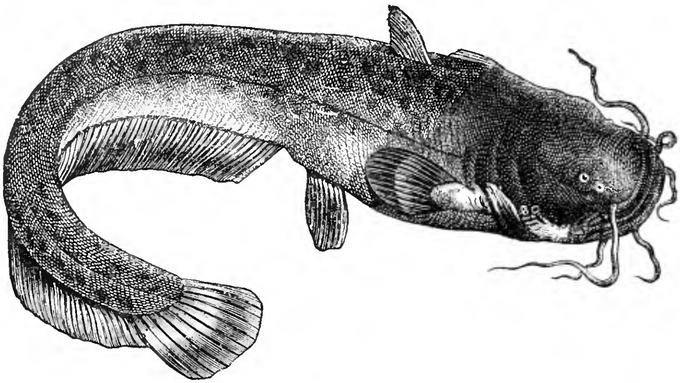


Fig. 29.—Catfish (*Silurus glanis*).

But perhaps we ought not to omit to mention the siluroids (Fig. 29), or catfish, for, although they are more like ordinary fishes than some of those already mentioned, their large, broad, and flat head, and large mouth with its fleshy filaments, give them a decidedly *outré* appearance, making them quite marked forms in the class of fishes.

As to the little blind-fishes (Fig. 30), or *Amblyopsidæ*, of the Mammoth Cave, they are very similar in general outline to ordinary fishes, but are peculiar in having the eyes rudimentary and concealed

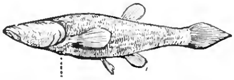


Fig. 30.—Blind-fish (*Amblyopsis spelæus*, Dekay).

Fig. 31.—Lamprey (*Petromyzon Americanus*, LeSueur).

under the skin, and in having the vent before the base of the pectoral fins at the point indicated by the dotted line in Fig. 30.

The eels are only or mainly remarkable on account of their elongated form. But the lampreys (Fig. 31), though eel-like in form, are not only different from ordinary eels in their structure, but very different from all the fishes we have hitherto noticed. Their respiratory

apparatus is very peculiar, being composed of seven pouches on each side, which receive water from the lateral openings of a canal distinct from the œsophagus, and discharge the same through seven branchial openings on each side of the neck; and their mouth and tongue are more strange than their breathing-apparatus. The mouth is round, and the tongue moves forward and backward in it like a piston, thus enabling the animal to produce a vacuum to fix itself firmly to a stone or any other body in the water.

As we get near the bottom of the scale in the examination of fishes, we find forms which, so far as their general outline is concerned, give no intimation of their true affinities. The myxines, or hags (Fig. 32), are of this sort: small fishes which have the general aspect of

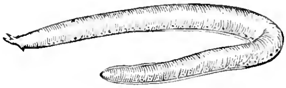


Fig. 32.—Hag, or Myxine (*Myxine limosa*, Girard).

Fig. 33.—Lancelet, or Amphioxus (*Branchiostoma*).

worms, but whose plan of structure shows them to be vertebrates, and whose circular mouth and piston-like tongue ally them to the lampreys.

And at the very bottom of the group of fishes we find the little amphioxus, or lancelet (Fig. 33); and how wide is the gap between this soft, nearly transparent vertebrate, without teeth or jaws, without skeleton or real head, and with only a mere slit for a mouth, and the typical fish as we see it in the shad, the cod, and the salmon! So little does the amphioxus appear like even a vertebrate, that Pallas, the naturalist who first described it, thought that it was some sort of slug or snail.

These strange forms of fishes are facts; and the important question is, What do they mean? What has caused them? What are they for? Will they continue? These and other questions quickly suggest themselves, and are easily asked; but are not so easily answered.

The whole subject of the origin and meaning of organic forms is a very important one. It is not so narrow as indicated by the questions asked above about the queer forms of certain fishes; but it is a subject which embraces inquiry into the origin and full significance of all organic forms upon the earth and within its crust.

Are these fishes and all other organic forms just as they were created? The creationist says "Yes;" the evolutionist says "No." Suppose we admit the doctrine that they were all created as they now appear—what does it mean that there are 15,000 specific forms of fishes, and that a thousand, or two thousand, more or less, are of these *outré* forms described above? Can any one give a satisfactory an-

swer? Or suppose we accept the doctrine of evolution and natural selection—does that, when we come right down to the facts as revealed in these 15,000 forms of fishes and all other organic forms, solve all the difficulties for us, or enable us to solve them? Does evolution alone enable us to account for the wonderful diversity of form, to say nothing of the scarcely less wonderful diversity of size, among these numerous vertebrates—especially when we remember that thousands of the most diverse forms have always been under essentially the same physical conditions?

Is there any rational explanation that we can yet give of such a form and structure as those exhibited in the torpedo (Fig. 4), in the sawfish and the hammer-head shark (Fig. 7), the chimæra (Fig. 9), the remora (Fig. 25), or the lamprey (Fig. 31)?

Is it not true that we have much yet to learn before we can give a satisfactory explanation of the wonderfully diverse forms in the animal kingdom, or even in a single group like that of fishes?

THE OBSERVATORIES OF ITALY.[1]

By Professor G. RAYET.

In the course of my journey in Italy, I visited successively the observatories of Palermo, Naples, Rome (that of the Roman College as well as that of the Capitol), Florence, Bologna, Modena, Padua, Milan, and Turin, remaining some time at each. There are thus no less than ten observatories in Italy, three times as many as in France; and from the proceedings of the Congress of Astronomers at Palermo[2] it appears that it is the intention of the Government to maintain all of them, each one being devoted, however, to a different branch, so as to fulfill the various needs of astronomical science, now become so complex.

Of these observatories, only that of Naples has a considerable number of assistants, and in no one is the work done under rigid regulations; each astronomer devotes himself, according to his predilections, to a special subject; emulation and the desire to make a name in science produce a continuity of effort the result of which has in

[1] Prof. Rayet, of Marseilles, has recently been deputed, by the Minister of Public Instruction of France, to visit the various observatories of Italy, and to report upon them. His report is published in the *Archives des Missions Scientifiques*, 3me série, tome iii., p. 529. As this work is not generally accessible, and as almost nothing is known in this country of the important steps now taking in Italy, it is believed that the following abridgment and translation of this report will be of value.—Editor.

[2] *See* Appendix to vol. iv. of the "Memoirs of the Society of Italian Spectroscopists," p. 37, *et seq.*

the last few years been manifest in various brilliant discoveries. To show this, it will be sufficient to describe briefly the situation of each observatory, and the work upon which it is at present engaged.

The Observatory of Palermo: *Director*, M. Cacciatore; *Astronomer*, M. Tacchini.—This observatory contains two important instruments: a meridian-circle, constructed in 1857 by Pistor and Martins (of Berlin), whose telescope has an aperture of 126 millimetres (4.98 inches), and an equatorial by Merz (of Munich), of 24 centimetres (9.45 inches) aperture, which, though built in 1857, was not mounted until 1865. The meridian-circle was employed in 1870 to determine the difference of longitude between Naples and Palermo, this last point being the fundamental station in the new topographical map of Sicily, and it is daily employed in observations of the sun and the principal stars. The most important work, however, of the observatory of Palermo, which is specially undertaken by M. Tacchini, is the daily study of the solar protuberances.

Since the total solar eclipse of 1868, a great number of astronomers have devoted themselves to the daily observations of these protuberances, in order to study their distribution on the solar circumference, and their relations with solar spots. Among these astronomers are Lockyer, Secchi, Rayet, Respighi, Tacchini, and Young, but it is in Italy that these researches are most vigorously prosecuted, and, in order to avoid the interruptions in a series which cloudy days may occasion, the observatories of Palermo, Rome, and Padua, prosecute these observations in common.

Every day, when the weather will permit, M. Tacchini makes a drawing of the protuberances surrounding the border of the sun and of the spots and faculæ which are upon its surface. These drawings, as well as those made at Rome and Padua, are subsequently published in the "Memoirs of the Society of Italian Spectroscopists," whose publications, begun in 1872, form already four large quarto volumes.

For this work, M. Tacchini makes use of the large equatorial of the observatory, and a direct-vision spectroscope made by Tauber, of Leipsic, which has two series of five prisms. These prisms are of rare excellence, for, in spite of their number, the spectral lines suffer no distortion. The spectroscope can be rotated on its axis so that it can be placed tangentially on any portion of the sun's circumference. Among the interesting historical instruments of the observatory is the altitude and azimuth circle made by Ramsden in 1788–'89, which served Piazzi in the preparation of his great catalogue of stars.

The Observatory of Naples: *Director*, M. de Gasparis; *Astronomers*, MM. Fergola, Brioschi, and Nobile.—The observatory of Naples is the most important of those of Italy, in its equipment and its personal establishment.

It was founded in 1812 by Murat, and it is built in agreement with

modern ideas. It contains numerous instruments which are maintained in perfect order by the care of an instrument-maker attached to the observatory. In the west meridian room are a transit-instrument by Reichenbach (aperture 117 millimetres = 4.61 inches), and a meridian-circle by the same artist (aperture 108 millimetres = 4.25 inches). These are still in use, and by means of them M. Fergola has lately determined the differences of longitude of Naples with Rome and Palermo. The east meridian room contains a meridian-circle by Repsold, which has just been mounted, and which is one of the best instruments of this class made by this celebrated artist. The telescope has an aperture of 163 millimetres (6.42 inches), and a focal distance of two metres (8.74 inches). It has a single graduated circle, one metre (39.37 inches) in diameter, and four microscopes.

It is with this instrument that M. Fergola is observing the zone of stars which the observatory of Naples has undertaken for the German Astronomical Society. Besides the three meridian-instruments the observatory of Naples has in active use two equatorials, and is soon to obtain a third of larger dimensions. The first of these instruments was constructed in 1811 by Reichenbach and Utschneider, and has 83 millimetres (3.27 inches) aperture. It is with this small instrument that M. de Gasparis discovered nine asteroids, *Hygea*, *Parthenope*, *Egeria*, *Eunomia*, *Psyche*, *Massalia*, *Themis*, *Ausonia*, and *Beatrix*. The second equatorial was made by Merz, of Munich, and has 134 millimetres (5.28 inches) aperture, and 2.06 metres (81.10 inches) focal length. The objective is of so perfect a figure that, in spite of its small dimensions, M. Nobile has been able to employ it in the measurement of double stars of Struve's catalogue. (These were discovered by Struve with an objective of 9.62 inches aperture.)

Observatory of the Roman College: *Director*, Padre Secchi; *Astronomer*, Padre Ferrari.—The observatory under the direction of Padre Secchi is built upon the top of the cupola of the church of St. Ignatius, near the Corso; but in so solid a way that the stability of the instruments, during the night at least, is quite satisfactory. The principal instrument of the observatory is an equatorial of 7.5 inches aperture, which is one of the *chefs-d'œuvre* of Merz. There is still another equatorial, by Cauchoix, of five inches aperture, which is used for the daily observations of solar spots, and also a transit-instrument by Ertel (aperture 92 millimetres = 3.62 inches), for time-determinations. The situation of the observatory, in the centre of the city, has forced its illustrious director to devote his efforts to the study of physical astronomy, which in his opinion is too much neglected in government observatories.

To enumerate the magnificent works executed in this branch of astronomy by Padre Secchi would require too much space, but I may mention a new experimental method used by Padre Secchi in his studies of the solar protuberances. For more than a year he has

employed in place of the prisms of his spectroscope a diffraction-grating ruled upon speculum metal by Lewis M. Rutherford, Esq., of New York City. This grating has 4,000 lines to the English inch, and gives a spectrum whose definition leaves nothing to be desired. For the study of the solar prominences such a grating appears to me infinitely superior to any combination of prisms.

OBSERVATORY OF THE CAPITOL: *Director*, M. Respighi; *Assistant*, M. Scarpellini.—The second observatory in Rome, that of the Capitol, is under the patronage of the *Accademia dei Nuovi Lincei.* It is placed upon the summit of the southeast portion of the palace of the Capitol, and it is sufficiently removed from the neighborhood of traveled streets to preserve it from the vibrations caused by carriages, etc. The instruments are undisturbed enough to allow of the most delicate astronomical observations, such as the determination of the nadir-point and the observation of stars by reflection from the surface of quicksilver, at all hours of the day.

The horizon is also entirely free, so that if the situation allowed of a more regular placing of the instruments it might be considered as very favorably situated for the making of observations of precision. M. Respighi is now occupied in observations of solar protuberances, and in meridian observations, which are to serve as a basis for a catalogue of stars. For the first purpose an equatorial by Merz, of four and a half inches aperture, and a direct-vision spectroscope with five prisms, are employed.

A beautiful meridian-circle by Ertel serves M. Respighi for his observations of those fixed stars of the first six magnitudes, which are to be employed by the Italian staff-officers in their geodetic operations. This observatory possesses also a reflex zenith-tube, made by Ertel from designs by M. Respighi himself. It is a sort of transit-instrument, with an aperture 108 millimetres (4.25 inches), provided with an eyepiece which contains three groups of declination-wires. The basin of quicksilver, by means of which the reflected stars are observed, is 21 metres (68.90 feet) below the objective, which thus masks but a small portion of the sky. When the telescope is directed toward the nadir stars very close to the zenith may be observed by the declination-wires during their transit; at the same time and without touching the instrument the nadir may also be observed, so that the zenith-distance of each star depends upon the micrometer-screw alone and is determined with the great accuracy which this kind of observation allows.

OBSERVATORY OF FLORENCE: *Assistant*, M. William Tempel.—The old observatory of Florence, formerly presided over by Donati, has been dismantled, and a new and magnificent structure is nearly built at Arcetri, near the house formerly inhabited by Galileo. The old observatory is now used for a meteorological station, under charge of Prof. Pitti.

The new observatory possesses: 1. A Fraunhofer equatorial of three inches aperture, suitable for a comet-seeker; and, 2. A large equatorial by Amici, of eleven inches aperture, of excellent quality. Besides this, a small meridian-instrument is mounted in the meridian-room. This room will subsequently contain a meridian-circle of seven inches aperture, and a transit-instrument somewhat smaller. It is proposed to have for this observatory a staff composed of a director and five assistants.

Observatory of Bologna: *Director*, M. Palagi.—The observatory of the University of Bologna is one of the most ancient in Italy, and, like all the observatories of the past century, it is placed on the top of a high tower, which unfits it for precise observations. In the plan proposed for the reorganization of the Italian observatories, this institution is to devote its labor to observations of physical astronomy. It possesses a meridian-circle, by Ertel, of forty-two lines (3.5 French inches) aperture, mounted in 1851, but now little used, and also a Dollond equatorial of three inches aperture. Its collection of historical instruments is of high interest.

Observatory of Modena: *Director*, M. Ragona.—Modena is an astronomical city, for in it or near it were born Amici, Secchi, Tacchini, Ferrari, and other Italian astronomers. The Ducal Observatory is, like that of Bologna, in a transition state. It was founded in 1819, by Bianchi, and was provided with the best instruments of that time, but it now will probably become the central meteorological station of the surrounding states. Its meridian-circle is of four inches aperture with three-feet circles, and was made by Fraunhofer and Reichenbach in 1819, but requires some changes to bring it up to modern requirements. Its Amici equatorial has two and one-third inches aperture only, and is thus too small for most astronomical purposes. Its collection of meteorological and magnetic apparatus is, on the contrary, very complete and noteworthy, and has been made, in most cases, upon plans furnished by M. Ragona.

Observatory of Padua: *Director*, M. Santini; *Astronomer*, M. Lorenzoni.—This observatory dates from 1774, when this city was placed under the protectorate of Venice, and when this powerful republic attracted the most celebrated professors to its university. It is well situated for observations of precision, as the numerous catalogues of stars published by its celebrated director, now the oldest living astronomer, testify sufficiently. The principal instruments of the observatory are a meridian-circle and an equatorial, both by Starke—the first of 117 millimetres (4.61 inches) aperture and with one-metre (39.37 inches) circles; the second with twelve centimetres (4.74 inches) aperture and two metres (78.74 inches) focal length. There is also a spectroscope by Hoffmann. The two latter instruments are used by Lorenzoni for daily observations of the solar protuberances. The meridian-circle is employed in observations of the sun,

planets, and the principal stars, and can even observe stars down to the tenth magnitude by means of a peculiar device for bright wires.

Observatory of Milan: *Director*, M. Schiaparelli; *Astronomer*, M. Celoria.—The Milan Observatory is one of the most ancient of Italy, its foundation in the Brera Palace having been established in 1760. Among its directors have been the celebrated astronomers Boscovich, Oriani, Cesaris, and Carlini. The Ephemeris of Milan has long been distinguished for its accuracy, and for the memoirs published in connection with it by Oriani, Cesaris, and Schiaparelli. The observatory contains two halls, one for the equatorial and one for the meridian-circle. The equatorial, by Merz, was mounted in February, 1875. It has an aperture of 218 millimetres (8.58 inches), and a focal length of 3.20 metres (125.99 inches), and its objective is of such an excellence that a magnifying power of 700 diameters is habitually used. It is to be devoted to a reobservation of Struve's double stars. The meridian circle is by Starke, and has an aperture of four inches and a focal length of five feet.

Observatory of Turin: *Director*, M. Dorna; *Assistant*, M. Charrier.—The present observatory of Turin was constructed in 1820, and until 1864 it was under the direction of the illustrious Plana; since that time it has formed part of the university, and is under the charge of the Professor of Astronomy. Its instruments are: 1. A meridian-circle by Reichenbach, with a circle one metre (39.37 inches) in diameter, and a telescope by Fraunhofer, twelve centimetres (4.74 inches) in diameter. This excellent instrument is used for observations of the sun and stars for the determination of the time, which is given to the city by means of a time-ball. 2. A comet-seeker of twelve centimetres (4.74 inches) aperture and eighty-two centimetres (32.28 inches) focal length, mounted in a small dome. 3. A repeating circle, by Ertel, used for purposes of instruction. 4. An equatorial of 117 millimetres (4.61 inches) aperture and 1.82 metres (71.65 inches) focus, which will be used by Dr. Charrier for spectroscopic observations of the solar protuberances. A larger equatorial is soon to replace this.

In terminating these short notes I must formulate in a few words the reflections which my visit to so many institutions has suggested to me. The simple enumeration of the instruments would ill suffice to judge of their importance. It is not sufficient that an observatory should be provided with numerous or powerful instruments: it is further necessary that these instruments should be at the service of accomplished astronomers earnest in the pursuit of their studies, and having no other desire than to achieve a name in science. In all these respects the observatories of Italy leave the most satisfactory impression upon the visitor. Thanks to this universal ardor, no moment is

lost; and Italian astronomy, which for a time languished, is reconquering with marvelous rapidity the rank which the labors of Galileo assured to it at the beginning of the seventeenth century.

ON DROPS.

By A. M. WORTHINGTON.

AMONG the many ways in which electricity is called in to give assistance in various physical investigations, one of the most elegant and interesting is the application of the electric spark to render momentarily visible a body that is rapidly moving or changing its form. The duration of the electric spark is so short—probably not more than $\frac{1}{24000}$ of a second—that a body, such as a rotating wheel or oscillating rod, moving in a dark room with extreme rapidity, will, if illumined by an electric spark, seem stationary, since the wheel or rod has not time to change its position appreciably during the short instant for which it is visible. If the spark be bright, the impression is left on the eye long enough for the attention to be directed to it, and for a clear idea to be formed of what has been seen.

The writer of this article has recently applied this method to watching the changes of form in drops of various liquids falling vertically on a horizontal plate. As usually seen, a drop of water falling

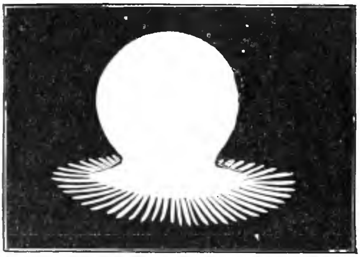


Fig. 1.

Fig. 2.

from a height of ten or twelve inches on a smooth solid substance, such as glass or wood, seems to make an indiscriminate splash. The whole splash takes place so quickly that the eye cannot follow the changes of form; the impression made by the last part of the splash succeeding that of the first part so quickly as to confuse it.

A little careful observation, however, shows that the drop passes through very definite symmetrical forms, and that a splash is by no means an irregular, hap-hazard phenomenon.

Let the reader let fall a few drops of milk, about $\frac{1}{4}$ inch in diame-

ter, on a smooth dark surface of wood or paper, from a height of, say, six inches (milk is better than water, as it is easier to see, especially on a dark ground); he will observe that the liquid makes a blot with a more or less regular undulated edge, but the splash is too quick to follow with the eye.

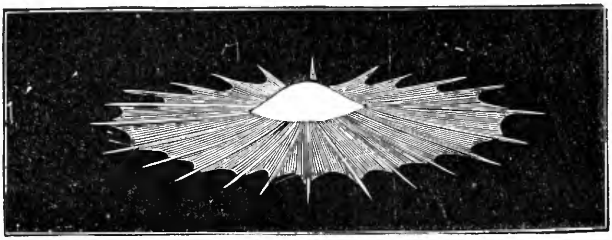


FIG. 3.

Let him now substitute a drop of mercury for the milk. By watching the splash very intently he will be able to catch a glimpse of the mercury spread out in the symmetrical, star-like form of *e*, Fig. 9. After the drop has been thus spread out it recovers its globular form, since the mercury does not wet the plate. On increasing the height of fall a few inches, it will be noticed that small drops split off in a more or less complete circle, and are left lying on the plate, while the rest of the drop gathers itself together in the middle of the circle.

The chief reason why these appearances could not be seen with milk is, that the milk wets the glass or wood and sticks to it, while the mercury does not. But by smoking a slip of glass or card tolerably thickly in the flame of a candle, we get a finely-divided surface of lampblack to which the milk does not adhere any more than the mer-

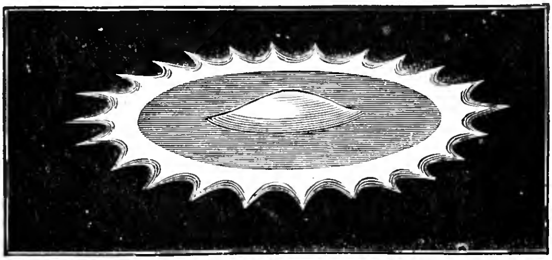


FIG. 4.

cury, and by very careful watching we may notice that the same radial star is formed by the milk, but it is much more difficult to catch sight of than the mercury-star. But if the mark on the lampblack be examined after the drop of milk or mercury has rolled away, it will be found to consist of delicate concentric rings with number-

less fine radial striæ where the smoke has been swept away. These may be seen very well by holding the glass plate up to the light if it has not been too thickly smoked.

The marks thus made are very beautiful and symmetrical, and it will be found, if the glass be uniformly smoked, that the same-sized drops of the same liquid falling from the same height will produce almost exactly similar marks: while if the height be changed the mark on the lampblack will be somewhat changed; and it is a fair inference, if each drop makes almost exactly the same complicated, symmetrical mark, that the splash of each drop takes place in almost exactly the same way.

The glimpse that may be caught of the drop in the way described is obtained when the drop is really almost stationary, having flattened itself out on the plate, and being on the point of contracting again to its original form.

That a drop if so flattened out will recover itself, is seen on pressing down a drop of mercury with the finger, or a drop of water with a piece of black-lead or other substance to which it does not adhere.

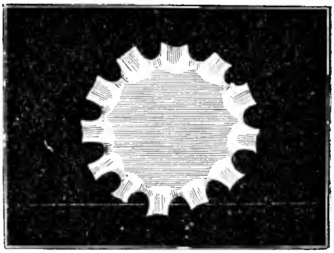


FIG. 5.

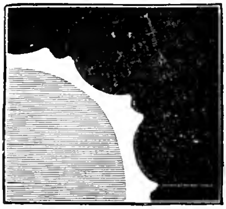


FIG. 6.

On removing the pressure the drop springs back to its old form; the force which causes this being exerted by the curved surface of the liquid at the edge of the flattened drop, on the liquid within. The flatter the drop becomes the greater is the curvature of the edge, and the greater the corresponding pressure tending to restore it to its original globular form. The extent to which a drop that has fallen on a plate will spread out depends on the velocity with which it strikes the plate, i. e., on the height of fall; so that as long as the drop returns to the globular form the whole phenomenon of the splash may be regarded as an oscillation similar to that of a pendulum; the velocity of the liquid outward being checked, overcome, and finally reversed by the ever-increasing pressure of the curved edge, just as a pendulum has its velocity checked, overcome, and finally reversed, by the action of gravity.

It is only when the height of fall is very great that the liquid flies off in all directions and the splash ceases to be an oscillation; this

case corresponds to that of a simple pendulum started with a blow so violent as to break the string.

But the liquid star and the complicated pattern on the smoked glass show that the splash is not a simple spreading out of the drop equally in all directions, to return again.

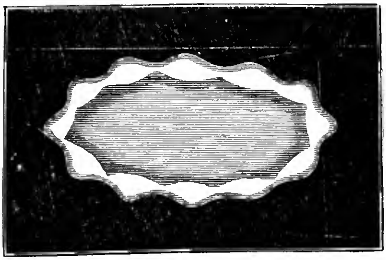


Fig. 7.

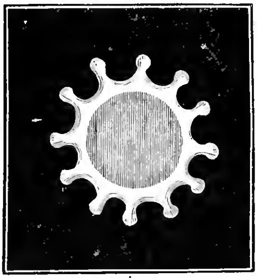


Fig. 8.

In order to observe the form of the drop at any given instant during the splash, it is necessary to make use of the electric spark, and to take advantage of the fact that drops of the same size falling from the same height will all behave in the same way.

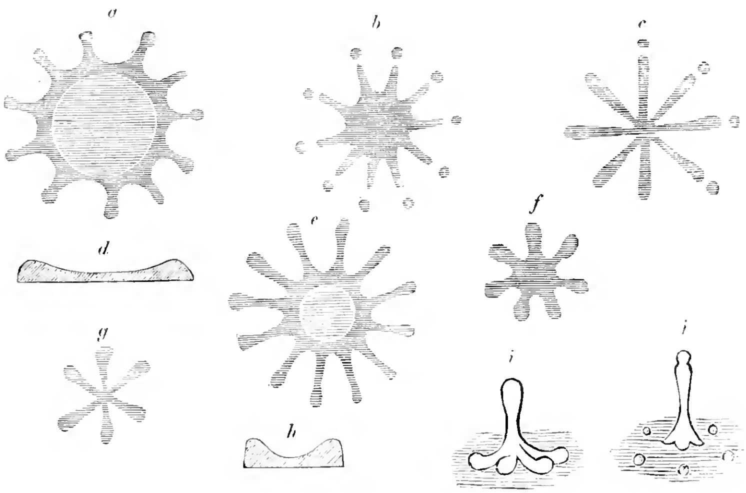
It will be necessary to let a drop, say of mercury, fall on a plate in comparative darkness, and to produce a strong spark at the instant the bottom of the drop comes in contact with the plate, and so illumine it; the observer will then see the drop in the form it has at that instant.

A second drop must be let fall in the same way, and be illumined by the spark not at the first moment of contact, but a shade later, say $\frac{1}{100}$ second later, when the drop will have spread itself out slightly on the plate; and similarly we must illuminate a third drop a shade later than the second, and so on. The observer can, after a little practice, draw from memory on each occasion the drop in the form in which he has seen it. It will be seen that the process consists in isolating consecutive phases of the splash from those that precede and follow, and which take place in darkness, and so do not confuse what has been seen as they would do in continuous daylight.

The device adopted by the writer for so timing the appearance of the spark as to illumine the drop at any desired phase of the splash consisted essentially in breaking the current of an electro-magnet at the instant the drop began to fall; the magnet, thus ceasing to act, releases a spring which immediately begins to pull the terminal wire of a strong electric current out of the other terminal, which is a cup of mercury, and the strength of the spring and the depth of immersion of the wire in the mercury are so adjusted that the wire leaves the surface of the mercury, and the required spark is produced at the instant the drop reaches the plate.

For the next drop the spark is made to appear a shade later, either by slackening the spring or increasing the depth to which the terminal wire is immersed in the mercury.

The accompanying figures have been drawn in the way described, and show the behavior of a drop of mercury abont $\frac{1}{7}$ inch in diameter, falling from a height of about three inches on to a glass plate. Each figure represents a rather later stage of the splash than the preceding.



Fig' 9.

Fig. 9 was drawn from the final stages of a milk-drop $\frac{1}{4}$ inch in diameter, falling four inches on to smoked glass; but the forms are almost identical with those of mercury. Of these *d* and *h* are vertical central sections of the middle part of the drop, while *e* and *f* are alternative forms of *b* and *c*.

From the ends of the rays of Fig. 4, usually twenty-four in number, small drops often split off. These are not shown in the figure. One of the most curious features of the phenomenon is the transition from twenty-four rays to twelve arms, shown in Fig. 5. The beauty of many of the forms, especially of the ridged, shell-like form shown in Fig. 4, when composed of shining quicksilver apparently rigidly fixed, is very striking. Very similar forms are obtained with milk, but, whether with milk or mercury, are liable to occasional variations. For a more detailed account the reader is referred to the "Proceedings of the Royal Society," Nos. 174 and 177, 1876–'77.—*Nature.*

CIVILIZATION AND MORALS.

BY J. N. LARNED.

IN bringing these two subject-matters of thought into conjunction with one another, I wish, if possible, to set them clear of all controversy at the outset. No attempt at a definition for either can escape dispute; but a merely indicative statement may be made in each case that will give form enough to the conception without touching any point of question in it. If I should say, for example, with Mr. Emerson, that civilization is "a certain degree of progress from the rudest state in which man is found," I should provoke the disputes that are rife as to what is and what is not "progress" for the human race. But I may safely say that civilization is a certain cumulative succession of modifications or changes in the state and character of men—which indicates the conception quite distinctly enough, and excludes every matter of debate. In like manner I may avoid the disputations of the ethical schools, and yet set out a notion of morals that will serve every present purpose of thinking, if I say that moral philosophy has for its subject *human conduct*, considered with reference to whatever *absolute qualities* may be found in it. It might seem, on the first thought, that this statement assumes the very thing that is in question between those who contend for the absoluteness and those who contend for the relativity of our ideas of right and wrong. But it is not so. The dispute of the moralists has reference, not to any characteristic of the qualities in conduct which we cognize as *moral*, but to the mode in which they are cognized. Our conception of such qualities involves the conception of absoluteness in them, and it is only by that notion of absoluteness that they are distinguished from the other qualities which appear in human conduct, such as wisdom, prudence, ingenuity, and the like. The imperative "*ought*," which puts its mark upon what is moral, in distinction from what is prudent or expedient, is just as autocratic in the doctrine of the utilitarian as in that of the intuitionist. The former, as Mr. Sidgwick has pointed out in his admirable analysis of "The Methods of Ethics," can only hold that the moral rules of conduct are means relative to an end (greatest happiness) by holding that the end itself is prescribed absolutely, and *ought* to be pursued. But absoluteness of end involves absoluteness of means, since means and end are inseparable—so far as human knowledge goes—and cannot be conceived of apart. Hence the qualities in conduct which the utilitarian finds essential to the attaining of the object that represents "duty" to him are just as absolute in his view as in the view of the intuitive moralist, who admits nothing objective in his notion of "duty." In what I have to say,

therefore, of that kind of quality in human conduct which we call "moral," I shall distinguish it only by its absoluteness.

Every act in the conduct of a human being is incident to some one or more of the varied relationships by which his state of being is conditioned. Fundamentally, there are four groups of such relationships, subject to which every act of man is performed: 1. His relationships to inanimate Nature, or to the matter, the forces, and the routine processes, of his physical environment; 2. His relationships to the living creatures with which he is associated in existence, that are not of his own kind; 3. The relationships that exist within himself, between the manifold parts of his own being; between that, for example, which is animal on one side and that which is more than animal on the other; 4. The relationships that exist between himself and his human fellows.

It might be expected, perhaps, that I should add a fifth relationship—that of man to the supreme source of being and of law in the universe; but this lies at the outside of what we are now investigating. It is a relationship to which nothing in human conduct can be incident primarily, however powerful an influence upon conduct may be referred to it secondarily. The emotions of religion, induced by a conscious relationship of responsibility to some supreme, divine government in the universe, give a color of their own, it is true, to the quality of human acts, but they do not assume to impart that quality nor to change it. Primarily, they have nothing to do with it—it is determined independently of them—and Religion has to do with the quality of human actions only by adopting the colder consciousness on which Morality is founded, and suffusing it with the warmth of reverential and impassioned motives.

Of the four groups of relationships to which all conduct is incident, the one first named does not fall within the region of morals, and the second only touches upon the borders of it. Without entering into the reasons of the fact, it may be seen that the kind of quality we are looking for in human actions cannot exist where the act is entirely conditioned by purely physical laws, as in the case of a man's dealing with the inanimate world. As he stands related to brute creatures, however, one new factor is introduced, which is that of sentiency, on the opposite side of the relationship, as well as on the side of the human actor, and we find in the conduct incident to this a single quality which we recognize as of absolute existence—inhering in the very nature of the act to which it pertains. For the positive phase of this quality, which is not exactly kindness and not exactly mercifulness, no name seems to have ever been adopted. In its negative phase we call it cruelty, and it appears to be, among moral traits, the primary one.

In the third group of relationships, embracing those which are

intrinsic in man (as between his ruling faculties and the organs which they rule, or between his reason and his will, on the one hand, and his affections, appetites, and senses, on the other), the field of moral investigation enlarges, but is still limited. There seem to be two forms in which the absoluteness of quality that we are searching after in human conduct is found appertaining to these intrinsic relationships. We have it, I think, in the qualities that we call truthfulness and courage, and I do not perceive it in any others within this category, except such as are no more than modifications and combinations of these, with their opposites. I cannot now go beyond this mere statement of a conclusion, unless it be to suggest that such distinguishable moral qualities as patience, fortitude, resignation, and so on, are modifications of the radical quality of courage; while another order of qualities, like temperance, chastity, and sincerity, have their root in truthfulness, or integrity, which may be the better name. Out of these two radicals there may be derived, I think, by combination and modification, all the qualities which I should classify as the moral qualities of the personal order.

The final set of relationships to be investigated is that which exists between the individual man and his fellow-men; and here the field of moral study opens to its widest dimensions. These social relationships are varied, numerous, and highly complicated by intermixture. It might be supposed that we should have to divide them into two principal groups, embracing—1. Such relations as exist between man and man individually; and, 2. Such relations as exist between the individual man and his fellows at large, in the united body which we call society; but it will be found that a man's relations to society are only the sum of his relations to the several members of it, and that society, in fact, is nothing more to him than a congregation of the persons between whom and himself he comes to recognize that there are relations of human fellowship existing. Nothing new, as a true factor in morals, is introduced by social organization—not even by the institution of government; because that is a mere arrangement for defining (sometimes arbitrarily and incorrectly) the relations between individuals. These relations between individuals, then, are what we have to examine, and they seem to divide themselves as follows:

1. The relationship in which one man stands toward another simply as a living creature. This is identical with the relation existing between man and brute animals, in the conduct incident to which we discovered no moral quality except that of cruelty and its unnamed opposite; and we need not go far in human history to find social states and circumstances in which no other relationship than this is often recognizable between men, and under which no other moral quality can often exist in the conduct that is incident to it.

2. The relationships which one man sustains to another as a human

fellow. These latter are partly *direct* and partly *indirect* or secondary relations.

The *direct relationships* in this case are those of a man to the concrete *person* of his human fellow. These direct relationships are simple and not very numerous, in fact, although they assume countless variations of circumstance and form. Some of them are special, like the relations that exist between parent and child and between husband and wife; some of them are limited, like the relations that exist between the sexes; and some of them are common and universal. In the conduct which is incident to these relationships there has seemed to be a great variety of distinguishable qualities of the absolute sort, and we have a lengthy catalogue of names in the nomenclature of morals to represent them; but I am disposed to believe that, after all, there are only two radical qualities (with their opposites) to be found in this sphere of human conduct. These are benevolence and justice. All the rest, which appear upon the surface as distinguishable moral qualities, I conclude to be either variations of these in degree and by circumstance, or else the resultant of some blending of them with the moral qualities of the other order. Such blending is necessarily incessant, because the relationships under which man is acting are always mixed. Mr. Lecky has given the name of the "amiable virtues" to a considerable group of these moral qualities, such as charity, generosity, magnanimity, mercifulness or clemency, kindness, and so on, every one of which would seem to have its root in benevolence, or in benevolence and justice combined, and to be merely circumstantial modifications of the same essential quality. Then we have, appertaining to this relationship, such qualities as fidelity and honor—if the two are really distinguishable—and both of these are clearly produced by an intermixture of the absolute personal quality of truthfulness with the absolute social quality of justice. Whatever else there may be of distinguishable moral qualities appearing to be incident to the direct relations of human fellowship, I am sure that they will be found reducible to the two radicals of benevolence and justice, or to their combination with those other radicals—courage and truthfulness—which we found to have an intrinsic source in the constitution of man, as qualitative factors in human conduct.

The *indirect or secondary relations* that exist between man and man as human fellows are those which extend to something additional to the person—to things, that is, which have become recognizably identified with the person. In these relationships the whole notion of "property" is involved. The idea of "property" is the idea of a special relation existing between a certain man and certain things, in recognizing which we necessarily recognize—1. That our own relations to those things are modified by it; and, 2. That it introduces a new set of relations between ourselves and the man, which are indirect, because the things in question are intermediate in them. Not only tan-

gible but intangible things become thus associated with the personality of our fellow-man, and give rise to these indirect relationships. His opinions and beliefs, his friendships and his reputation, the objects of his affections, the franchises that he acquires under the artificial institutions of society, are all examples of the intangible things which become intervening subjects and objects in many of the relationships that a man sustains toward his fellow-men. The indirectness of the relationships thus created is productive of great complexity in them, and gives rise to much confusion of moral notions with reference to the conduct that is incident to them. Out of all the complications that arise, however, there is not one distinctly new quality evolved. We distinguish in this region of conduct such absolute characteristics as those of honesty (under many names) and tolerance, but they are all of the composite class, and have their root, for the most part, in justice and truthfulness intermingled, with benevolence sometimes imparting its amiable tone to them.

As the result of our survey, then, we have discovered but four absolute qualities in human conduct that are simple and radical, while we have traced a very few of the numerous qualities that are composite, or derived, to the relationships out of which they arise. We have:

Of radical qualities of the personal order—courage and truthfulness.

Of radical qualities of the social order—benevolence and justice.

Of derived and composite qualities of the personal order—temperance, chastity, fortitude, patience, etc., with their opposites.

Of derived and composite qualities of the social order—two classes, viz.:

1. Incident to direct social relationships: charity, generosity, magnanimity, mercifulness, kindness, fidelity, patriotism, etc., with their many-named opposites.

2. Incident to indirect social relationships: honesty in all its forms, and with all its opposites, which are numerous in the nomenclature of morals.

Having acquired, so far as this, a partly definite notion of morals, we may now return to take up the conception of civilization, and bring the two sets of ideas into conjunction.

I did not venture to say of civilization that it is "a certain degree of progress" in the state of man, because there are those who deny that the cumulative succession of changes, in man and society, which appear in the process called civilization, are, on the whole, progressive changes. Their denial, moreover, has reference entirely to the moral features of the process. They do not question the fact that human history, in the civilized communities, is a history of intellectual development and advancement. They concede the largest claims that can be made as to the growth of knowledge among men; as to the

growth of capacity in them for the knowledge of knowable things; and as to the growth of power in them to control the material conditions of their existence, within such limits as are set by physical law. They do not belittle the modern triumphs of the race in commerce, science, art, invention, and organization. But they look upon all this as an evil, delusive, vainglorious show—a devil's work of tinsel and veneer—a bubble-blown fabric, quite empty of the substance of eternal things. They insist that there has been no moral growth in human nature, as a whole, to accompany the evolution of rational faculties and powers; and that, while human conduct has been gathering its potent gains of prudence, ingenuity, skillfulness, and the like—which are qualities relative to means and ends—it has gained, on the whole, in the absolute qualities of rightness and goodness, either nothing at all or less.

This denial of moral progress, as a general fact, is made, however, with some necessary qualifications. There are certain moral fruits so conspicuous in the history of civilization, that no pessimist can dispute them. That the long, slow movements in society, which have been tending, with steady purpose and sure result, to establish order and the reign of equal laws; to extinguish slavery; to break oppression of every form; to mitigate the barbarities of war, and to put restraints upon it; to diminish human suffering; to help the unfortunate, and to lift the debased; to cultivate the cosmopolitan sentiment and the spirit of coöperation among men—that the movements which bear this ripening fruitage are moral movements, it is impossible to deny. However the sullen pessimist may disparage them, as sentimental and superficial, the moral quality in them is unmistakable. He yields, therefore, to the evidence of a moral growth of human character in these amiable directions, but he contends that it is all awry, and more deforming than otherwise in the result. He points to the other sides of the historical exhibition of humanity, and asks us what we can find to please us in the total showing. Is there less hypocrisy among men, he demands to know, than there was twenty centuries ago? Is there less chicanery, less duplicity, less grasping greed and selfish meanness? Is there less rapacity, in fact, after all the rude violence that you have subdued by softer manners is taken out? Is there less ruthlessness in the pursuit of ambitious or avaricious ends? Has any nobler type of character been fashioned by all your schools and institutions than the type of Socrates and Plato? Is your democratic Yankee, with his newspaper, his caucus, his party "platform," and his patent ballot-box, a more admirable patriot than the grim republican of old Rome? Is your modern mechanic, with his cunning tools and his marvelous engines, a more honest workman than the patient cathedral-builders of the middle ages? Is your modern merchant, with his steam carriers, his electric messengers, and his bills of credit, a more scrupulous speculator than the camel-driv-

ing trader of old, who fetched and carried between Babylon and Tyre? Such questions as these are not easy to answer, and very few persons will be willing to meet them with affirmations, in any positive and unqualified way.

We are brought, then, face to face with the fact that there are certain directions in which the process of civilization appears to be much more certainly a process of moral development, as evinced in human conduct and character, than it does in others; certain particulars of conduct, that is, in which the fact of moral progress is undeniable, and certain others in which, at least, it is open to doubt. Now, this is assuredly a fact of great significance. For the inference is plain that, if the progress of the race in intellectual culture and in social organization is attended with a certain moral development in some particulars of conduct more distinctly than in others, there must be reasons for this difference, and most likely they will be found in some bearing which the one process of culture has upon the other. It is to pursue this suggestion a little that I have taken the subject up.

The moment we pause to reflect upon the difference in question, one fact concerning it arrests attention. It is this: that the particulars of conduct in which the moral advancement of the human race is most obvious and indisputable are exactly and entirely those which we have seen to be incident to the *direct* relations of human fellowship, and that the qualities developed are entirely those which appertain to that relationship, having their root in benevolence and justice alone. On the one hand, charities, friendships, institutions of kindly helpfulness, and all generous, gentle amenities of social intercourse; on the other hand, charters, ordinances, constitutions—defined equities and broad determinations of personal rights: these are plainly the greater moral fruits of civilization which show signs of approach to ripening, as yet, and they all lie within the domain of those *direct* relationships which exist between man and man as human fellows, and which connect themselves with nothing else.

This fact leads us quickly to the recognition of a second one, which becomes just as plain on examination—namely, that the particulars of conduct in which the moral advancement of mankind appears most questionable are exactly and entirely those which we have seen to be incident to the *indirect* relations of human fellowship; to the relations, that is, which involve some intermediate thing, through which the line of relationship to our fellow is drawn. These take in, as has been said, all the relationships in which "property" is concerned, embracing the whole organization of trade and of labor under hire; and they also take in a great part of the political relationships that arise out of the institutions of government. Now, it is undeniably in these spheres of conduct that the moral effects of civilization present the most discouraging appearance. Are men as honest in work and trade as they were in more primitive times? Is there not more trickish-

ness, more cheating, more fraud, more overreaching, more adulteration, more sham, more outside pretension and inside falsity? Are they as true in political action to the state in which they have united and incorporated themselves? Is there as much genuine patriotism? Is there not more political corruption and neglect of political duty? These are certainly the questions which stagger the optimist most.

Here, then, we discover that the particulars of conduct between which the widest difference of progress in moral culture appears are precisely those that we have already separated by one of the broad differences that were found when we classified the relations to which human conduct is incident. It is natural to conjecture that the one difference may connect itself with the other. It becomes still more natural when we perceive that the characteristic difference which distinguishes the two sets of relationships in question has been widened by the process of civilization. On one side, the *direct*, primary relations that exist between men, in their purely personal attitude toward one another, have been steadily pressed into greater intimacy and closeness, at every step of advance which has been made in the diffusion of knowledge and in the social organization of the race, while they have been more and more generalized in the same operation. On the other side, as the industrial, commercial, and political mechanism of society has acquired more complexity and greater extension, the *indirect* or secondary relations, which involve the fact of property, etc., have been all the time undergoing variation and multiplication, and have been shaped into forms of greater remoteness, as between the persons and the things that are concerned together in them. The effect in the one case has been to set out the relationships in question more clearly, to define them more distinctly, and to render them more easily recognizable as they widen; and it is within the sphere of this effect that we have the progress of moral culture most marked. In the other case the effect has been to obscure most of the relationships in question, and to render the clear perception of them more difficult as they lengthen out; and it is within the range of this effect that we find most doubtful evidences of moral growth in the process of civilization.

From this I shall now venture a generalization, to see whether it will be justified by further scrutiny of the moral history of mankind, and I offer it in the following propositions:

1. That moral notions, or notions of rightness in conduct, are formed in the mind by the perception of certain relations to which human conduct is incident; that they are exactly akin in nature, therefore, to mathematical notions, and have their genesis in the operation of the same faculties; that there is no more need, in consequence, of a special "moral sense" to account for them than there is need of a distinct mathematical sense to account for the perceptions and reasoning processes of arithmetic and geometry.

2. That "rightness" in conduct is just as absolute a quality as "straightness" in mathematical lines (from which it takes its name), and can no more depend for its existence upon the "utility" that is found in it, or upon its coincidence with the experience of happiness among men, than the existence of the quality of straightness in mathematical lines can depend upon the utility with which it serves the architect and the engineer, and coincides with the necessities of mechanical art.

3. That our moral notions of right and wrong, with reference to each particular of conduct, are distinct and complete in exact proportion to the clearness and fullness of our perception of the relations which that particular of conduct appertains to; that their influence in the guiding of our conduct depends upon the distinctness with which they have thus been formed; but that our obedience to the guidance they offer depends upon something else, which we shall have to investigate hereafter.

Let me illustrate these propositions as briefly as possible:

It seems to be historically certain that man's cognition of the *alter ego*, or other "self," with which he finds himself associated in existence at every turn, is slowly acquired at the beginning of it, and that his conception of that other "self" (or fellow-man) is formed gradually by the projection upon it of ideas that have grown in his own self-consciousness. There are social states still existing, as I have said, in which one man's cognition of another seems to be very slightly different from his cognition of brute creatures, and we may take these to represent one of the primitive stages of human development. But progress occurred in the evolution of consciousness, until the attributes of the subjective "self," which it had cognized first, became more or less perfectly projected upon an objective "self," and one man recognized in another a repetition of the same fact of existence which he found in his own being; in other words, he arrived at the recognition, more or less perfectly, of a human fellow. At this stage moral notions and sentiments had their beginning, exactly as mathematical notions began when two external objects were distinguished from one another, and yet cognized together as two instead of one. There would follow some perception of a relation between this conscious "self" and that other cognized "self," and it would be perceived as the definition of a rule of conduct between them, just as surely as there followed in the other case a perception of the relation in position that exists between one object and another, and which conditions every act that involves the two. In both instances the fundamental idea generated by the perception must be the idea of a line—a "line of conduct" in the first, a "line of motion" or a "line of position" in the second—and the quality of "rightness" which attaches to the conception of the one is identical in kind with the quality of "straightness" that attaches to the other.

The golden rule of conduct, "Do unto others as ye would that they should do unto you," is strictly analogous to a mathematical definition; or, rather, it is the translation of such a definition into the language of morals. It is not only the formula of an equation, but it is precisely equivalent to the definition that we give of a right line when we say that only one such line can be drawn between two given points, and that to attempt to project another in reverse direction is only to repeat the first. It simply states the recognition of a corresponding fact—namely, that the line of right conduct projected from my "self" to another "self," which I have cognized, is such that no different line can be projected from that other self to me. What the line of right as projected *to* me from my fellow is, I am taught by my consciousness of the demands that exist in my own being.

In this way men first acquired, perhaps, the notions of right which produced a certain imperfect respect for life and liberty among them, and also a certain respect for property, according to the primitive idea of property, which was a narrow one. But, of course, these notions were restricted to the small social range within which the relations of human fellowship had become even indistinctly recognized. How limited that range was at the beginning, it is impossible to say; but our earliest knowledge of the human race finds it everywhere bounded by associations of kinship. The patriarchal family, the clan, the *gens*, the tribe, seem to have always, at a certain stage in the development of humanity, circumscribed for each man his recognition of other men as human fellows, and his perception of the relations which he sustains to them as such. Within that close circle of recognized relationships, however, we can find in the primitive states of society almost as perfect a determination of moral rights and obligations, so far as many particulars of conduct are concerned, as we find in the civilized communities of the present day. We know that, among the Indian savages of our own time, theft and murder within the membership of a tribe are condemned as distinctly, almost, as they are among ourselves; but as between tribe and tribe, or between Indian and white man, neither killing nor stealing connects itself with any apparent sense of wrong. The fact seems to have been the same in all the earlier tribal forms of society, and when the succeeding form was reached, in the organization of the political state, the larger boundaries of that social corporation still circumscribed the moral notions of its citizens just as rigorously.

In the ancient Gentoo laws of India, which show admirable notions of honesty as between the subjects of the laws, we find prescriptions for dividing the booty of robbers who had plundered any contiguous but alien people. "If any thieves," says the ordinance, "by the command of the magistrate, and with his assistance, have committed depredations upon and brought booty from *another province*, the magistrate shall receive a share of one-sixth of the whole," etc.

In ancient Greece, even at the golden prime of that splendid narrow culture which exhibited itself so incomparably in art, in literature, and in civic virtue, the moral rules which concern liberty and life, and the simpler of the moral rules which concern rights of property, were defined very perfectly as between the fellow-citizens of each state, and between the kindred states, but very imperfectly beyond that strict limit of familiar association. The stranger, the alien, the enslaved captive, the barbarian of the non-Hellenic world, were not human fellows to the Greek; at the most they were only human creatures of some different variety, having that similitude and approaching somewhat to that relation, but quite excluded from his cognition of fellowship by all the habits of his feeling and his thought. According to his perception, they were clearly proper subjects of predatory warfare and piracy; he could kill them, plunder them, enslave them, with no more compunction of conscience than the modern hunter feels in capturing or killing the game-animals of the forest. And yet the same conscience was acting in the Greek that acts in men to-day; but only with more narrowness of range in the perceptions upon which it acted.

We shall have to pass far beyond the Greek in history to find much of a moral change in these respects. The Englishman of the Elizabethan age was a tolerably cultured man, as well morally as otherwise. So far as his fellow-Englishmen were concerned, he had notions of right conduct that were quite accurately formed. But he found it hard to carry many of these notions beyond the shore-bounds of his little island. The sea in that time—not only the Spanish Main, but the English Channel, and the very Thames itself—was swarming with English pirates and buccaneers, who were the contemporaries of Shakespeare, and Bacon, and Spenser, and Coke; who boasted the best names of the English gentry in their ranks; who received more than half countenance from the public sentiment and the public policy of the English nation; and who pillaged Spanish, French, and Flemish traders with serene impartiality, killing captains and crews without remorse when it suited their convenience to kill. In fact, Mr. Froude tells us that the well-encouraged piracy of the sixteenth century was "the very source and seed-vessel" of the future naval power of England.

This insulation of moral ideas, which established one code of conduct for fellow-citizens and another for foreigners, one code for neighbors and another for strangers, characterized every people until recent times; but it has been disappearing rapidly among all the foremost races since the modern growth of universal commerce began. There is no mistaking the reason why. In the footsteps of commerce, every kind of communication and intercourse between men has closely followed, like the threads behind a weaver's shuttle. By travel, by migration, by correspondence—through the post, the newspaper, and the telegraph—men are fetched nowadays from the farthest corners

of the earth into acquaintance with one another. For the civilized man of our time, most of the world has become a neighborhood. He interests himself in the life and doings of another hemisphere much as he does in the affairs of his own town. He cannot help losing the sense of strangeness and of remoteness in his cognition of other men, even though they inhabit the antipodes. He cannot resist the influence of the association into which he is thrown with all men, of all nations, races, classes, and creeds, and he necessarily extends to them, more and more in common, his recognition of human fellowship. In other words, he generalizes more and more his notions of right conduct toward men, because his clear perception of those relations of fellowship upon which such notions are based has become a general instead of a partial one. This accounts for the whole humane movement of modern times toward democracy, toward the breaking of caste and the leveling of class divisions, toward emancipations and enfranchisements, toward equity in institutions and laws, toward common education and toward public and private charities of every kind.

It is not the fact, however, that every man acquires entirely for himself these larger and more intelligent perceptions, which broaden and clarify his notions of right. There is the same giving and taking in this as in other matters of knowledge. Men accept from one another a great deal of what becomes the serviceable common stock of knowledge in every department. We are all of us settled now in the belief that the earth is round, that it revolves about the sun, that it rotates on its axis, that the other planets do the same, and that these motions are all controlled by the same force, under the same law, which governs the fall of a ripened apple from its stem; but how many comprehend the mathematical proofs by which such beliefs as these are sustained? The belief makes its way among men by the force of the authority of the few, whose keener faculties have verified the demonstration of it—assisted, indeed, by the general growth of what may be called a receptive intelligence, which enables men to discern the probability of the truth of things which they do not perceive clearly in fact. But such beliefs are accepted at last and acted upon and reasoned upon, exactly as though they held in each man's mind the firmest ground that his own perceptions and his own reason could give them. It has appeared to be the same with all the larger generalizations in morals. They are diffused in society by the propagation which we call a growth of public opinion, and they sometimes enforce themselves in the moral code of a community even before the major part of its members have half recognized the ground of fact upon which they rest.

If we turn now to the *indirect* relationships between men, which arise out of the institutions of property, politics, etc., we shall see that they have been generally rendered more remote and less recognizable, by the same operations that have produced greater intimacy and fa-

miliar closeness in the *direct* relations of person with person. This fact is particularly apparent in the relationships which involve property. The primitive idea of property was so associated with the fact of possession or occupation that it could not be entertained apart from that. According to the earlier Roman law, stolen property was lost to its owner, simply because he had lost possession, without which the moral intelligence of that age could not retain its conception of the right of property. If recovered from the thief, it was appropriated by the state. In the later Roman jurisprudence this inequity was corrected, but it reappeared in the legislation of the barbarian conquerors of the empire, and again became the law of Europe for several hundred years; surviving in some parts of Germany, according to Chancellor Kent, until near the middle of the last century. By the common law of England, as laid down even so lately as in the Commentaries of Blackstone, goods wrecked were adjudged to belong to the king, and the owner had no right of recovery until a curious statute of Edward II. gave him that right, upon the condition that some living creature should have escaped the wreck, to fictitiously represent him, it would seem, in the act of possession at the last moment.

This strange defect in the primitive idea of the right of property, lingering so obstinately and so long, illustrates the difficulty which men have always experienced in carrying that idea from a simpler to a more complicated set of circumstances, and the easiness with which their perception of the relations to which it attaches becomes confused by any separation, whether real or apparent, of the thing from the person. But, in the evolution of our civilized social state, more complex forms of property have been coming all the time into existence. In some of these, the person and the thing have been pushed apart to a wide remove from one another; in others, the association of ownership between them is subtilely conditioned by various circumstances and contingencies; in others, several persons are associated with the same thing, in common ownership, or with a succession of rights in it, or with rights that are various in degree; in still others, the thing which is the subject of property is a pure figment of the brain—the mere idea of a property-right which has itself become property by a convenient fiction. Again, half the wealth of the world has been acquiring of late a kind of duplicate shadow-form of existence, by paper representation, in a hundred modes—as in bonds, notes, drafts, stock-certificates, bills of lading, etc.—and so plays a double part, one real and one fictitious, in the commercial transactions of the present day. That this protean mobility of form should be given to "property," and the subjects and conditions of ownership be so continually multiplied and modified, without obscuring the indirect relations which "property" creates between men, and confusing the perception of them, is quite impossible. Along with this obscuring cause there is another

one to be found, which has been equally active in the whole arena of industrial and commercial intercourse. This is the constant multiplication of intervening agents—middle-men, factors, brokers, speculators, contractors, and distributors of every sort—between the producer and the consumer, or between the primary owner and the ultimate owner of almost everything which is the subject of ownership and trade. Those two, who are the actual persons brought chiefly into relationship by the thing in question, are put quite out of sight of one another in most of the transactions of modern industry and commerce; and it is easy to see how much more energy in the forming of a notion of right is required to preserve the integrity of the line of conduct between them, through indirect dealings like these.

The truth, then, seems to be that the civilizing process in society has, thus far, had two quite contrary moral effects: one, to cultivate and quicken in men the intelligence which apprehends their relations to one another, and which perceives a right line in all the conduct that is incident to those relations; the other, to complicate and obscure one prominent group of such relations, and to make the apprehension of them more difficult. If the former effect has not yet overcome the latter, in that sphere of conduct where the conflict between them is greatest, there is nothing to wonder at in the fact. It is quite according to the nature of our moral cognitions that men should sooner learn not to steal than not to cheat: because stealing is an assault direct upon that fact of *possession* which we have seen to be at the bottom of the idea of a right of property; whereas cheating takes most of its suggestions from the absence of that fact. It is certain that civilization has diminished downright robbery, depredation, theft, and not so much by its police, nor by the force of its penal laws, as by cultivating the notion of right conduct which condemns them. If it has not yet curtailed the devices of fraud, and if men make dishonest use of the knowledge and the skill that they have gained in every art, even more, perhaps, than their fathers used the scantier methods of fraud which they knew, the reason seems to be explained, and I can find nothing in the fact to argue against a final ripening of moral fruits in this region of human conduct, as well as in the rest.

"But what then?" every reader will ask. "Is it enough to account in this way for our notions of right? Is it enough to satisfy ourselves that they are formed like our mathematical notions, by the same faculties, in the same way, and that they have the same intellectual genesis? Is there not something more which this doctrine leaves still unexplained?—that something which distinguishes a moral notion from every other that is formed in the human mind; that something in it which is mandatory and urgent; that something which we call conscience, sense of duty, obligation?" I say, Yes; there certainly is something involved in morals beyond the knowledge of right and wrong; some kind of a force, or some kind of a law of feeling in man,

which constrains him toward the right line of conduct when he has discerned it. That it only operates in coincidence with his perception of the line of right—that men, in other words, have no conscience with respect to wrongful deeds which they have not yet recognized as wrongful—appears to be shown by all the facts of human history. If it were otherwise, the Greek should have had a conscience to protest against infanticide; the Roman should have had a conscience to protest against slavery and against the bloody games of the arena; the Jew should have had a conscience to protest against the slaughter of women and children in war; Calvin should have had a conscience to protest against the burning of Servetus, and Cotton Mather a conscience to protest against the witch-hunting deviltries at Salem. This conscience, then, must be something that is only made active by the development of a moral intelligence which reveals to men the line of right in one particular of conduct after another. Need we try to account for it any otherwise than by calling it a *law of feeling*, analogous in kind to that law of motion which operates to constrain the obedience of matter to right lines of motion? We know that, when we throw a stone into the air, it would move forever in the straight line of its projection if other forces, more potent than the projecting one, did not interfere to overcome the proper law of its motion. If, now, we might imagine a state of consciousness in this clod of matter, by virtue of which it could *feel* the resistance in itself to the perturbing forces that are swerving it from the line of rectitude, we should have the perfect analogue of what I conceive to be the conscience of the human being; a persistent law of feeling, that is, in man, which resists deviation from the right lines of conduct whenever he has become conscious of them. Such an implanted law of moral feeling in human nature is no more difficult of conception, nor any less so, than the rectilinear law of material motions.

But if the moving stone were conscious of the commanding law which resists all perturbing influences, it would still be irresponsible for its deviations from the right line of motion; whereas the acting man is not, because all the forces, of projection and perturbation alike, are in himself, and within the control of his own volition. He has but to bring his will into conjunction with the resisting *vis inertiæ* in his moral consciousness to make the resistance always efficient.

And this brings to light the third element in morals: which is the discipline of obedience in man to the law of feeling which constrains him toward the right line of conduct when he has perceived it. This discipline is very obviously the final end and final fruit of human culture. We need not wonder that it is slowly attained, when we think of the powerful animality in man which has to be struggled with in the process. It may be that our modern civilization has accomplished little as yet beyond the older in this direction, of moral discipline. It may be that men have acquired larger perceptions of right without

being trained to obey them any better, except in a few directions of conduct, where the least resistance of opposing appetites and passions is encountered. But still it must be true that all culture tends, first, to develop the moral intelligence which forms right notions of conduct, and, finally, to perfect the moral discipline which makes conduct obedient to them.

It is upon that discipline chiefly that those qualities which I have called the moral qualities of the personal order, and which have their root in truthfulness and courage, depend for their evolution. I had intended to recur to these for some discussion at this point, but my article is already too long. Perhaps it is enough to note the fact that, being incident as they are to intrinsic relations, self-existing in man, which undergo no complication and no change, the moral notions that define them may easily have been quite as distinct at some earlier stages of human culture as they are now. If they manifest themselves no more potently in conduct than they did twenty centuries ago—which seems doubtful, upon the whole—the fact must show us how little our modern civilization has yet advanced the race in moral discipline, whatever gains in moral knowledge it may have brought.

DOES IT TAKE TIME TO THINK?

(SOME MEASUREMENTS OF THE PERSONAL EQUATION.)

By T. F. BROWNELL.

MASKELYNE, the Royal Astronomer of England, in August, 1795, had his attention called to the fact that his assistant, Mr. Kinnebrook, was making errors in recording observations. He noticed that Mr. Kinnebrook had fallen into the habit of making his records half a second later than they should be. In the following year this fault was found to have increased. All of Mr. Kinnebrook's observations were recorded as about four-fifths of a second too late. The assistant was a trained and skilled observer of long experience, but, although the fault was pointed out to him, and realized by him, it appeared impossible for him to overcome it. The same error still appeared in all his work. The two astronomers, it must be remarked, were working together observing and noting the same events, such as the transits of the same stars across hair-lines placed in the fields of vision of their telescopes or transit-instruments. After observing side by side a large number of events, and recording the times as accurately as they could to the second and fraction of a second in each case, it was found by a comparison of results that the events were almost invariably recorded by Mr. Kin-

nebrook as having taken place four-fifths of a second later than the time observed and noted by Maskelyne. All attempts by Mr. Kinnebrook to account for or to remedy what he deemed his fault were in vain. At last Maskelyne, assuming that his own observations were correct, and that the habit of his assistant arose from some defect difficult to explain, felt obliged to discharge him as incompetent for the special class of work in which he had been long engaged. At the present day astronomers, with better knowledge of the degree to which the personal element enters into all work, and especially into a class of labor so difficult as that of recording fractions of a second or hundredths of an inch, are accustomed to place as much reliance upon the observations of Mr. Kinnebrook as upon those made by the royal astronomer himself. The constant difference in the result is explained, not by the assumption of incompetency on the part of one of these astronomers, and of complete accuracy on that of the other, but by reference to what is known as the relative personal equation of the two men. It is not supposed that the records made by either of them are absolutely correct. Beyond a doubt there is in the records of each a small and constant error arising from personal characteristics. There is no reason to suppose that the amount of this error was larger with Mr. Kinnebrook than with Maskelyne. The absolute personal equation, as the error is called, is as likely to appear in the observations of one as in those of the other. The error of four-fifths of a second, which invariably appeared, does not represent a difference from the exact truth, but the constant difference between the amount of error habitual to one of these observers and the amount of error habitual to the other. But, as we do not know the personal equation of either, in this, which is the first recorded case of the kind, we can never know where the truth actually was.

By this and similar cases the attention of scientific men was called to the effect of personal characteristics in classes of work similar to that of the astronomical observatory. Examination showed that these characteristics are a constant cause of error. By numerous experiments it appeared that one who observes and records an occurrence always gives a result which differs from the exact truth. Even where the observer was trained and skilled in observing events like those in the experiment, the rule was the same. He recorded the time too early or too late. The error would appear in each experiment, and always to the same amount. If the record was too late in one, it invariably was too late. This habitual difference between the time as noted by an observer and the actual time of the happening of the occurrence is what has been termed the absolute personal equation of that observer. It represents the amount of error which he will always make. It has been found to differ with different persons for the same class of events. It also differs in the same person for events of different classes. The time required to observe and

record the happening of a sudden and unexpected spark, for instance, is always greater than that required in the case of the expected appearance of a letter or figure thrown upon a screen. The equation also differs according as the facts are observed by the use of one of the senses or of another. The time required for some of the senses to convey intelligence to us is far greater than that required by others.

In making astronomical observations the equation requiring attention is that relating to the sense of sight. Being the value of an habitual error, it invalidates all observations, since the record of each observer is incorrect in a certain constant amount. It is, therefore, necessary to obtain the personal equation of the observer, and to add or subtract this from the results which he notes, in order to know the true time of the occurrence recorded by him. This can easily be done. To obtain the equation for observation of the transits of stars, for instance, the method is quite simple. A luminous point similar to a star is made to move with uniform velocity in a circle, and to pass across the field of a telescope. The exact time the point is upon the hair-line which divides the field of view is correctly recorded by mechanism which stops a chronometer. The observer watches the luminous point, and as soon as he sees it upon the line presses a button which stops a second chronometer. The difference between the times indicated by the two chronometers gives the personal equation of the observer for the transits of stars, recorded by pressing a button. Its amount will be very small. When the time is taken by glancing at a clock and then noting, the equation of almost all observers is so large as to demand a correction.

Since personal characteristics are the cause of a constant error, it follows that two observers of equal skill, using instruments of equal accuracy in observing and recording a large number of occurrences, will always differ from each other in the results obtained, and in an amount that will always be the same. This constant difference between the results given by two observers is called their relative personal equation. The four-fifths of a second between the records of Mr. Kinnebrook and Maskelyne was the value of such an equation. It is the sum or the difference of the amounts of error habitual to each. Its value may be found by experiment, or by adding together the absolute equations of each, or by subtracting one from the other in case the tendencies to error are in the same direction.

An interesting example of a personal equation was the ground of a serious criticism made about a year ago upon the trustworthiness of the observations made at Greenwich. In timing the class of observations which were criticised, the record was kept at the observatory in seconds and tenths of a second. The first record was made at the time of the observations by dots or punctures made in a tape running over a drum, the spaces between the dots representing cor-

responding lengths of time. The tape was prepared for use by being marked off by printed dots, about a third of an inch apart, into spaces representing seconds. The permanent record was prepared subsequently by reading off the results noted upon the tape. To read off the whole seconds was of course a simple matter of enumeration of spaces representing seconds. The fractions of a second, however, it was customary to estimate in tenths of a second. The estimation was made upon the position of one sharply-marked dot as referred to two other well-defined dots, one on each side of it, indicating the beginning and the end of a second, and separated about a third of an inch. It was done by inspection of the tape, by highly-trained and experienced men, to whom it had been a daily work for years. Such being the methods, an astronomer connected with another observatory selected at random from the reports of the Greenwich Observatory a large number of records, and caused the number of times each fraction of a second occurred to be counted. Theoretically, there is no reason why one fraction should appear more often than another. An examination of over 1,200 instances, however, showed that certain fractions appeared much more frequently than they theoretically should. The figure 4 or $\frac{4}{10}$, and the figure 0 or $\frac{0}{10}$, were found too often. Upon this fact was founded a criticism upon the accuracy of the reports. It was claimed that the frequency of these fractions was occasioned by personal characteristics in the person who estimated the fraction; and it was assumed that such were the idiosyncrasies of even the most highly-trained persons, that in making such estimations they would unconsciously tend to use certain figures rather than others; in this case it was argued that the tendency causing error was to make the record four-tenths for most fractions between three-tenths and five-tenths, and where the dot was near the end of a second to record the time as a whole second. This criticism was offered in a dignified and serious way in a prominent scientific journal, and was as earnestly replied to and discussed by the observers at Greenwich in the same journal.

This example of the personal equation is quite different from that which was first briefly described. The value of the equation in this case it is impossible for us to formulate with accuracy in the present state of our knowledge. In examples like the first, the factors can be more readily observed, analyzed, and measured. The difference which appeared in the case of Maskelyne and Mr. Kinnebrook arose, without doubt, from the fact that nervous and mental actions require time for their accomplishment, and because the rate of nervous transmission and mental action in one of these observers constantly differed from that in the other. The problem of the personal equation in this aspect becomes one of physiology and psychology. As such it has been investigated with great research by specialists during the past twenty years. And, although the results obtained are in most cases only

approximately true, the various experiments that have been made are not without some curious interest.

It is well known that the operations of the nervous system require time. The action of the different senses is not instantaneous; there is always an interval of time after a foreign body touches our skin before we know that it touches us. So also between the mental decision to make a movement and its actual execution there is a real though short interval.

Where upon sight of a star a button is to be pressed, there is, first, the action of the sense of sight which gives us knowledge of the existence of the star; and, second, action of the will causing pressure of the button. In fact, the physiological and psychical action, in all cases where excitation is followed by the giving of a signal, may be divided into six separate and successive actions. The sensation may be divided into three distinct acts. In the example supposed there is, first, the reception of the image of the star upon the retina; second, the transmission of the stimulus through the nerve from the eye to the brain; and, third, the mental perception of the existence of the star. The voluntary movement which causes the signal may also be divided into three acts. There is, first, the act of the will by which it is determined to press the button; second, the transmission of the impulse through the nerves from the brain to the hand; and, third, the excitement of the muscular fibres by which the finger is bent and the button pressed. The entire interval between the excitation and the giving of the signal, during which these six acts occur in succession, has been called the physiological time. It is really the same in amount, in most cases, with the personal equation. That portion of it which is occupied with the purely mental acts of perceiving the signal and determining the signal is called the psychical time. It is the time required to think.

Attempts have been made to measure each of these six factors, and interesting results have been obtained, though of various degrees of accuracy and trustworthiness.

The earliest experiments were made with reference to the rapidity of movement through the nerves. The first attempt to measure the velocity of nervous impulses proceeding from the brain under action of the will was made long ago by Haller. He ascertained, by reading aloud with great rapidity extracts from the "Æneid," the average number of letters which he could pronounce in one minute. Then he calculated the length of the nerve from the brain to the muscles of the tongue and mouth. Each letter he regarded as requiring a nervous impulse. He was obliged then only to multiply the number of letters spoken in each minute by the length of the nerve. This gave as a result that the rate of nervous transmission from the brain was about 150 feet a second. This experiment was defective in failing to take into account the facts that both the act of willing and that of

muscular contraction require time. Had these been considered, the solution would have been farther from the truth than it really was. Recent investigations of more precision have not, however, given results that differ widely from that obtained by Haller. The rate as given by Helmholtz, after many experiments, is about 111 feet per second. This is now generally accepted as the most accurate statement. Slight differences in results for movements from the brain, and for those proceeding to it, have been obtained in the investigations, but the rate is regarded by the best authorities as essentially the same for both movements. If there be a difference, it arises because the rate of voluntary impulses moving from the brain outward is the more rapid of the two.

A difference also has been found to exist in the rapidity with which we perceive impressions received through the eye, and those received through the ear. This at one time was supposed to be caused by a difference in the rate of transmission in the respective nerves. The better authority now is that the disparity is occasioned either by difference of length of the two nerves, or because the mind does not so readily distinguish impressions of one kind as those of the other.

If these data are correct, it requires at least one-twelfth of a second for us to perceive a sensation in our foot. A mosquito which selects our ankle as the field of his operations has nearly a sixth of a second in which to make his escape, for it requires at least one twelfth of a second for us to find out that the mosquito is there, and another twelfth of a second for us to make up our mind to declare war upon him and to initiate hostile action.

It will be observed that the rate of nervous transmission is comparatively slow. Electricity travels at the rate of many thousand miles a second, or, more accurately, 16,000,000 times as fast as nervous action. Light moves about two-thirds as fast as electricity. If we examine movements which are comparatively sluggish, we find that a cannon-ball, when fired, moves about 900 feet a second, or nearly ten times as fast as nervous energy. A railroad-train speeding along at sixty miles an hour would be moving at about the same rate as an ordinary nervous stimulus, though in a contest the stimulus would probably win.

By further experiment it has been determined that the time required for the excitation of the muscular fibres for such acts as the supposed pressing of the button, this being the factor last in order of the entire six, is about one-hundredth of a second.

It is also declared with some precision, both by analogy to this last act and by experiment, that the time required for the reception of the impression by the sensitive membrane, which is the first and a corresponding factor of the complete physiological time, is also about one-hundredth of a second.

There are now left undetermined only two of the factors. These are the time required for the two purely mental acts: first, of perceiving the sensation; and, second, of willing the movement which immediately follows. These two make up the psychical time. It may be obtained by first learning the entire physiological time, and then subtracting from that the value of the four known factors, the determination of which has been given. This would leave the period required for the purely mental operations of distinguishing and willing.

For the purpose of learning the physiological time for events of different orders, a large number of carefully-prepared experiments have been made by different investigators. Though the results arrived at lack much in accuracy and completeness, they are highly interesting and instructive.

For experiments relating to sight the arrangement is usually of the following nature: The patient is seated before a screen, upon which certain letters or numbers can be thrown, or before glass globes, which can be suddenly illumined by an electric spark. Upon seeing the number, letter, or illumination, as the case may be, the patient immediately gives a signal by some slight movement of the hand or foot. Nice arrangements are provided, by which both the event and the signal register themselves, giving the time exact to the thousandth of a second.

The general result of many experiments is, that the time required for ordinary persons to distinguish an appearance and to give the signal amounts to about one-fifth of a second. Exactly speaking, in the experiments of one scientist, the time required was found to be .188 of a second. In trials made by three other investigators the results have been .200, .205, and .194 of a second respectively. None of these conclusions varies much from one-fifth of a second. A comparison has also been made between cases where the event was an electric spark and others where the event was the passage of a luminous point across a line, the signal being the same in each experiment. According to one series of trials, it was found that the time required in the former case was .200 of a second and in the latter only .077 of a second. In other words, the perception and signaling of the former occupied three times as much time as in the case of the latter.

In experiments with the sense of hearing, the arrangements are generally of the same nature. The event is usually the sound of a bell or note, or of a spoken letter or number. For this sense the physiological time has been calculated to be about one-sixth of a second. Four investigators give .148, .1505, .180, and .182 of a second, as the exact results of their experiments. It will be noticed that the physiological time for the sense of hearing is shorter than for that of sight. We hear more quickly than we see.

For the sense of touch there is a discrepancy in the results thus far given by different investigators. According to the best authority, it appears that the physiological time in this case is about one-seventh of a second, and less than that of sight or hearing. Some, however, make it somewhat larger than this, and place it midway between those of sight and hearing.

Having thus found the entire physiological time by many carefully-prepared experiments, and having previously obtained, as has been briefly pointed out, the value of four of its factors, the value of the remaining two can be readily obtained by subtracting. We should then have the time necessarily employed in purely mental acts of distinguishing or recognizing an event and willing the signal.

One careful investigator, after experiments in which the event was the sounding of a bell, and the signal was made by pressing with the foot, tabulates the result with the following precision:

Time occupied (in seconds) by the mechanism of hearing the bell	.010
By the act of perception of the sound and of willing the signal	.112
By the transmission of nervous impulse through the spinal cord and nerve of the leg to the foot	.088
By the mechanism of muscular contraction in moving slightly the foot	.010
Total physiological time	.220

This is only slightly more than one-fifth of a second.

The two mental operations, it will be perceived, occupy somewhat more time than is required for the transmission of the impulse to the foot, and a little more than one-half of the entire time.

In all the tests thus far given the operation of the mind is as simple as possible. The terms of the problem are reduced to their lowest forms. Upon the simplest kind of a perception, and that expected, the patient is required to exercise his volition in the simplest way. There is no necessity of making comparison between two or more sensations, or of deciding between two or more courses of action.

But in the following experiment the mental acts required were more complex. The patient, upon receiving a slight shock given to the right foot, was to give the signal by moving the right hand, and upon receiving the shock in his left foot he was to give the signal with his left hand. He was left in ignorance upon which foot the shock was to come. It was found that under these circumstances the physiological time was prolonged one-fifteenth of a second beyond the corresponding time where the patient was informed which foot was to receive the shock. In the latter case there was no need of reflection, but in the former he was obliged first to decide which foot was touched, and then to decide upon the corresponding signal. One-fifteenth of a second represented the time required for these acts of the mind.

A similar test was made for the sense of sight. For a red light

the signal was to be given with the right hand, for a white light with the left hand. In this case the mental action of deciding these alternatives and coördinating the corresponding act of volition required no less than .154, or nearly one-seventh of a second.

Other experiments have been made with the sense of sight, where the patient was instructed to give the signal by pronouncing the name of a vowel which was shown to him. If he had to distinguish between two vowels, the psychical time was prolonged .166 of a second beyond what it would have been for one vowel. If he was required to name one out of five, the prolongation was increased to .170 of a second.

Similar experiments with the sense of hearing, where the vowel was spoken to the patient and repeated by him, gave similar results. Where two vowels were selected from the mind occupied .056, and where five were used .086 of a second longer than if only one expected vowel were spoken.

Where two colors were shown, and the signal was given by a movement of the hand, or by the voice, the physiological time for the movement of the hand was found to be always greater than for the voice.

When the signal was the pronouncing of a vowel, as "i," the time required was less than when the patient was obliged to speak the vowel with a consonant before it, as "pi," or "ki," or "ti." The letter "p" was found to retard the patient .011 of a second, "t" twice as long, or .022 of a second, and "k" .021 of a second. A further result of these curious investigations was that the patient required three times as long to distinguish between two letters which were shown upon a screen as to distinguish between the two corresponding vowels when spoken.

In all these investigations the psychical time is made up of two periods: the first required by the mind to perceive the sensation or to distinguish the alternative, the second required for the mental act of willing the signal. An attempt has been made to measure each of these. The experiment for this purpose was so arranged that the patient was to hear several vowels,.but was directed to give the signal only upon hearing a certain one of them. Under this arrangement the patient concentrated his attention upon the perception of the vowel at hearing which he was to act. He prepared himself, as far as could be, to pronounce it the moment he heard it. Before he heard it he willed to speak it on the instant that he should perceive it. There remained only the act of recognizing the vowel when it should be spoken, of distinguishing it among the other vowels. The act of volition was in this way eliminated from the physiological time, and the simplest mental act of distinguishing was calculated from the result. This result, based upon this and similar experiments, was that the mental act of distinguishing required about one twenty-third of a second of time. The whole psychical time being about one-twelfth

of a second, the time required in ordinary cases for the remaining act of willing was easily calculated to be about one twenty-eighth of a second. If these investigations can be regarded as entirely trustworthy, they tend to show that the mind perceives somewhat more slowly than it wills.

Of the personal equation, in its widest sense, there are many examples even more suggestive and worthy of extended treatment than these which have received mathematical measurement. These examples are to be found in all human action, and in the result of all human work. Noticeably is this true in all acts and occupations which have their basis and lowest forms in acts of imitation. None the less is it true in those higher forms of art and action where close imitation is less desired than the interpretation of some pervading spirit, or the representation of some underlying essential. In the acts of painting a landscape, of copying a picture, of interpreting a symphony, of reading a poem, of acting a play, of following an argument, or in any of the common or artistic acts of men, be they mental or physical, the personal equation of the actor enters as a perceptible element in the result. The discussion of the nature and value of the personal equation where it appears in forms so subtile as in the cases last mentioned would furnish many considerations of interest and instruction, but to undertake the treatment of these forms is beyond our present purpose or opportunity.

ABORIGINAL POTTERY OF THE SALT-SPRINGS, ILLINOIS.

By GEORGE ESCOL SELLERS.

IN the work by the late J. W. Foster, LL. D., on the "Prehistoric Races of the United States of America," published in 1873, when treating of the pottery of the mound-builders, on page 248, he says:

"On the Saline River, Gallatin County, Illinois, according to MS. notes of Prof. Cox, there is, just above low-water mark, a salt-spring, which was resorted to in the earliest settlement of the country, by those of European descent, for the purpose of procuring salt by evaporating the brine. Here occur, however, numerous fragments of pottery, showing that a prehistoric people had resorted to the same spring, and for the same purpose. From the slight curvature of the fragments it is evident that the vessels were of large capacity. The material is coarse, and the general thickness of the vessel is about half an inch, but at the rim it is three-quarters of an inch. The exterior is marked by vertical lines of depression about half an inch apart, with bars less conspicuous and close together, sometimes at right angles, and at others oblique. When I first saw these specimens, I was somewhat surprised that the makers should bestow so much ornamentation on vessels so coarsely made, and applied to such ordinary uses;

but a slight examination showed me that these figures had been impressed and not carved; *or, in other words, that a basket of rushes or willows had first been constructed, inside of which the clay was moulded and allowed to dry before burning.*"

Then, in a foot-note, he continues:

"Since this chapter was written, I have seen a paper of Mr. Charles Rau, of New York, on the aboriginal pottery of this country, in which he refers to this locality, and arrives at the same conclusion as myself. . . . I had occasion to examine a fragment of a vessel sent to Dr. Davis in 1859, by Mr. George E. Sellers, who obtained it at the salt-springs, near the Saline River. . . . Several acres, Mr. Sellers states, are covered with broken vessels, and heaps of clay and shells, which indicate that they were made on the spot. They present the shape of semi-globular bowls with projecting rims, and measure from thirty inches to four feet across the rim; the thickness varies from a half to three-quarters of an inch.

"The earthenware has *evidently been moulded in baskets.* It is solid and heavy, *and must have been tolerably well baked.* The impressions on the outside are very regular, and are really ornamental, proving that these aboriginal potters were also *skillful basket-makers.*

"Mr. Rau quotes from Hunter, as to the aboriginal mode of making pottery, 'Another method practised is to coat the *inner surface of baskets, made of rushes* or *willows*, with clay, to the required thickness, and, when dried, to *burn them* as above described.'"

My object in writing this article is to refute a theory that would attribute to the rude, prehistoric people of the Stone age a skill in manipulation that cannot now be approached by the skilled artisan of the present age; that is, keeping in form and lining with heavy clay fragile baskets of the large size of these old salt-kettles.

About the time I sent the specimens to Dr. Davis referred to by Mr. Rau, I also sent some to the Hon. Thomas Ewbank, and in my letter accompanying I stated that I had discovered what at first I took to be an entire kettle bottom-up; but, on removing the earth that covered it, it appeared to be a solid mass of sun-dried clay. From its position among heaps of clay and shells, its hard, compact, discolored—I might say almost polished—surface, I became satisfied it was a mould on which the clay kettles had been formed, precisely as in loam-moulding at the present day.

Mr. Ewbank, in reply, said he thought I was mistaken; that what I took for a mould was most probably a concreted sediment that had filled a kettle and been turned out; that there was no evidence of the aborigines of either North or South America having ever used the lathe, or formed their ware by striking; not even among the Peruvians, whom he considered far in advance as to forms and quality of pottery-ware. They had moulded bottles or jugs on *gourds*, and open vessels in *baskets*, which had been burned out or off in baking; he thought the specimens I sent him bore evident marks of reed baskets, etc.

Before presenting the facts that have confirmed me in my original view of the manner in which these salt-pans were formed, and that I may be better understood, I will endeavor to describe the location where the fragments are found.

My first visit was in company with my friend the late Dr. David Dale Owen, about the year 1854. We found two water-worn ravines, commencing on the hills that rise abruptly on the south side of the Saline River, and drain into it. At the base of the hills they are crossed by a State road, between which and the river their bottoms are level, hard, and barren, and here, close to the road rise the salt-springs. Between the ravines is a bench or river-bottom subject to annual overflow.

These bottoms, as well as the hill-sides, were covered with a thick growth of young timber—the primitive forest having been cut off for fuel for evaporating the brine at the time the salines were worked by the early settlers. The principal spring was then, and is now, known as the "Nigger" well or salt-works, as it was worked by slave-labor while the State of Illinois was a Territory.

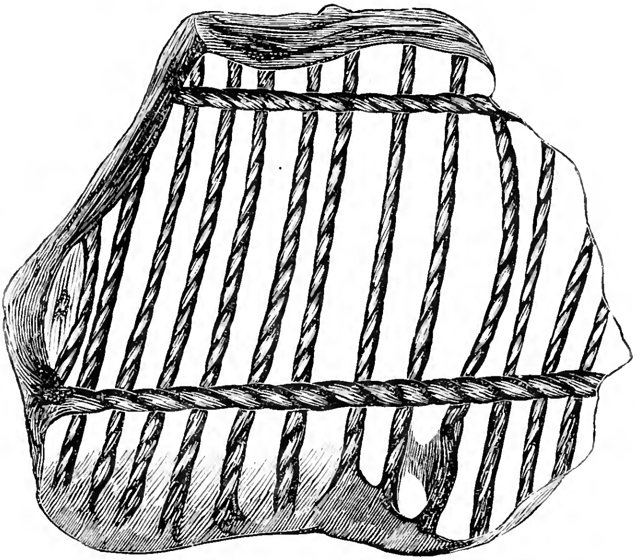


FIG. 1.

The spring in the west ravine overflowed a curbed well about eight feet square, which I sounded, and found to be about forty feet deep. In the east ravine a salt-spring was oozing. A short distance above the curbed well flows a sulphur-spring, and near it one of good fresh water.

I have been informed, by a reliable party who had personal knowledge of all that was done by the early settlers in working the salines,

that in the east ravine they sunk a well and curbed it down to the bed-rock, a depth of 42 feet, and made a boring of about 150 feet in its bottom. That all the way from the surface to the rock they found pieces of broken pottery, and on the rock a pitcher or jug, with a handle within the rim; this jug was sent to the Philadelphia Museum. My informant expressed the opinion that, at the time the aborigines used the waters, the spring had its outlet at or near the bed-rock, and had since gradually filled by surface-washings, just as the well in the west ravine has been filled since my first visit, and is now a cattle-tramped salt-swamp.

The present outlet of the spring is not over six or eight feet above low water of the Saline River, and the character of its bed precludes the possibility of its ever having been on a lower level; for at Island Ripple, within two miles of the spring, the river falls over a broad reef of rocks which backs the water—forming a pool—up to this place, where there is another slight ripple.

This, to me, is conclusive evidence that, whoever the people were who left the masses of broken pottery as proof of their having used the salt-waters, they resorted to precisely the same means as did their more civilized successors of our time—that is, sinking wells or reservoirs to collect the brine; and the dipper-jug which had been dropped had sunk to the bottom, showing that their reservoirs were down to the rock.

Running nearly in an east-and-west course on the south side, and close to the outlet of the springs, is an upheaval that has brought the carboniferous limestone to the surface standing on edge. The sulphur and fresh-water springs rise south of the line of this dike. On the line of it, about the centre of the raised bottom or plateau between the two ravines, say ten or twelve feet higher than the springs, and embracing an area of about eight acres, occurs a sink of about 120 feet in diameter. It was on the raised rim of this sink that I discovered the heaps of clay and shells, and what I took to be the inside mould or core on which the kettles had been formed. It was then a pool of water, around which I found the most abundant remains of pottery, not only represented by fragments of the large, coarse salt-pans, but by many pieces of small vessels of much finer texture, and of superior workmanship, such as would be used for domestic purposes. From these and large quantities of chippings and offal, I inferred that this was the site of the old settlement. The broken pottery, the black soil, the waste from long occupancy extending a considerable distance both east and west of the springs, and to the foot of the bluffs on the south, covering an area of about thirty acres, were confirmatory of this view; but the fact of the annual overflow made me look further for a permanent settlement.

The hills at this point run nearly an east-and-west course, forming a range of upheaval that crosses the State of Illinois, from the

Ohio River at Shawneetown to the Mississippi, and at some places attains a height of about 700 feet, being the highest land in Illinois or in either of the adjoining States of Missouri, Kentucky, and Indiana. Immediately south of the salt-springs is a spur of the main hill, its northern terminus being precipitous bluffs of metamorphic sandstone, which Prof. Worthen, the State Geologist of Illinois, who once visited the location with me, classed with the Chester group. Above this bluff, where the spur rises at an angle of about 30°, it has been terraced, and the terraces as well as the crown of the spur have been used as a cemetery: portions of the terraces are still perfect; all the burials appear to have been made in rude stone cists, that vary in size from eighteen inches by three feet, to two feet by four feet, and from eighteen inches to two feet deep. They are made of thin-bedded sandstone slabs, generally roughly shaped, but some of them have been edged and squared with considerable care, particularly the covering-slabs. The slope below the terraces was thickly strewed with these slabs, washed out as the terraces have worn away, and which have since been carried off for door-steps and hearthstones.

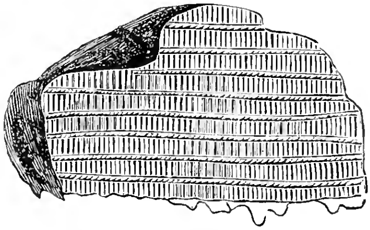


Fig. 2.

I have opened many of these cists; they nearly all contain fragments of human bones far gone in decay, but I have never succeeded in securing a perfect skull; even the clay vessels that were interred with the dead have disintegrated, the portions remaining being almost as soft and fragile as the bones.

Some of the cists that I explored were paved with valves of freshwater shells, but most generally with the fragments of the great salt-pans, which, in every case, are so far gone in decay as to have lost the outside markings. This seems conclusively to couple the tenants of these ancient graves with the makers and the users of the salt-pans.

The great number of graves and the quantity of slabs that have been washed out prove either a dense population or a long occupancy, or both.

On the crown of the main hill above the cemetery are ranges of circular depressions, from one to three feet deep, and from fifteen to twenty-five feet in diameter; they cover a large area, on two sides of which there is evidence of earthworks.

I had the soil removed from one of these depressions, and found marks of long-continued fire in its centre, from which I infer that they are sites of the lodges of these ancient people.

The general character of this portion of the hill-range is precipitous to the north, with a very gradual descent to the south, forming the north slope of the broad and beautiful valley of Eagle Creek, a tributary of the Saline, a valley once cultivated by the prehistoric people that worked the salines, evidenced by the fine specimens of stone agricultural implements turned up by the plough, and most abundant near the earthworks.

I have in my collection, from this locality, four hoes or spades, flaked out of chert or quartzite, most probably from the metamorphic sandstone of the district. They are beautifully wrought, and vary in size from six and a half by three and a half to ten and a half by four and three-quarter inches, and from one-half to three-quarters of an inch in thickness.

On receipt of Mr. Ewbank's letter in 1859, I examined carefully quantities of specimens of pottery, and found the markings on all of them to have been made by *woven cloth* of *twisted threads*, and in no single instance by rush or willow baskets. Some of these cloth impressions were of fine texture.

When I considered that a basket of the large size of these salt-kettles, even if made of metallic wire no thicker than the thread impressions, could not possibly be kept in form while being lined with heavy clay, the idea of using any twisted textile fabric for such a purpose seemed absurd. We must, therefore, look for some other explanation of these markings.

They could not be for ornament, or the rough, sharp edge of the projecting rim would have been finished with more care, or where threads had broken, or pieces been torn from the cloth, the defects in the markings would have been repaired.

Some of the threads of the cloth being at right angles to the rim, and gradually becoming oblique or bias, presented the exact appearance which a bandage of cloth would, if tightly bound round a semi-globular bowl.

I imagine these half-civilized people to have been practical utilitarians; and I can see the use of a bandage in holding the moist clay firmly bound while being raised from the mould on which it was formed, and which was essential to prevent cracking as it hardened or dried.

If a bandage was used in this manner and for this purpose, there could probably be found pieces of the pans showing the width of bandage used, also where and how it had been fastened at its union.

Therefore, my first object was to secure all the specimens that I could, also the mould or core on which I believed the pans had been formed. But from the time I collected the specimens sent to Mr. Ewbank and Dr. Davis, it was nine or ten years before I again had an

opportunity of visiting the springs. I then found the plateau between them cleared and under cultivation; the water had dried from the sink; a crop of corn was growing on its bottom; the plough had overturned and broken the mould, but in doing so had exposed portions of others of the same character. They appeared to have been small mounds built of stone, and covered with a tenacious yellow clay, which, by sun-drying, had become as hard as common salmon-brick.

From the position of the moulds on the rim of the sink, I inclined to the opinion that it was mainly an artificial reservoir for water, and the centre of a great pottery-manufactory; the material used being the siliceous fire-clays and shales of the coal-measures, which are found in abundance, decomposed and ready for use, in ravines within reasonable distance of the locality, together with fresh-water shells from the reefs and ripples of the Saline and Wabash Rivers, using bivalves and univalves indiscriminately.

The plough had played sad havoc with the pieces of pottery I expected to secure. At first, pieces ten or twelve inches across were easily obtained; now one as large as the hand is a treasure: this breaking up made it very difficult to secure the evidence I was looking for. I made many thorough searches before finding any specimens of well-marked unions of the bandages, or establishing conclusively that in no case were the bottoms of the large vessels marked, as they would have been if formed in baskets.

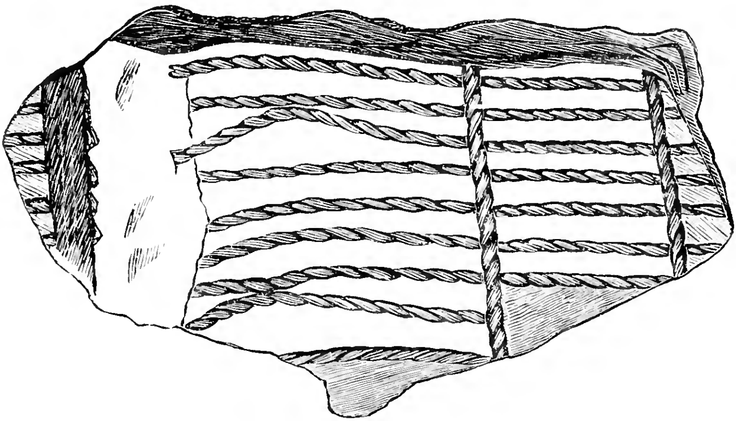


FIG. 3.

A person familiar with the work of the early settlers informs me that, in grading for foundations of their salt-furnaces, several of the large pans, almost perfect, were unearthed and destroyed by the black laborers. He paid no attention to the markings, only observing that their bottoms were perfectly plain, and described them as "basins, as large around as the hind-wheel of his wagon, with flattish bottoms."

At the present salt-works, about five miles higher up the Saline River, on its south fork, near Equality, is the "Half-Moon Lick," where the earth has been licked away to a depth varying from twelve to sixteen feet, in the shape of a horseshoe, about 200 yards from point to point of the heels, and to the toe, or back of the curve, 250 yards. In this lick are still to be seen deeply-trodden buffalo-roads. On one bank is a slightly-raised ridge, in which were found imbedded a number of earthen vessels in a row. Mr. B. Temple, one of the proprietors of the salt-works, described them to me as between four and five feet diameter and sixteen to eighteen inches deep. After uncovering, they were not removed, but suffered to go to decay. The bones of the mastodon have been found here.[1]

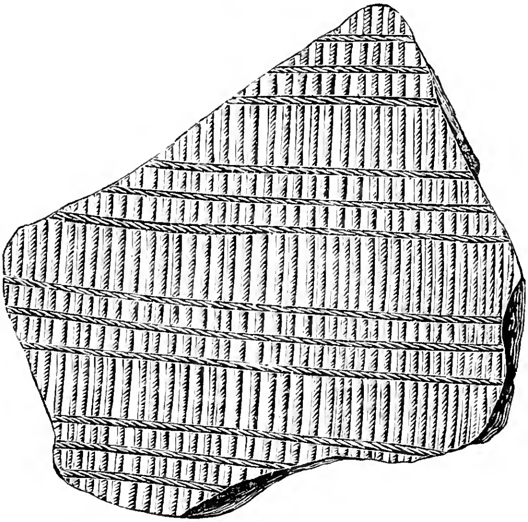


FIG. 4.

On many of the fragments of the large pans in my collection the impressions of the cloth are perfect delineations of the fabrics used. Though differing greatly in pattern and in fineness of texture, they are all, with one single exception, made or woven in the same manner—that is, by twisting two threads of warp around the single thread of the woof, precisely as the wire faces of laid moulds for forming paper are now made. The coarsest fabric that I find the impression of has warps about one and a half inch apart, with about five threads of woof to the inch. This piece is shown full size in Fig. 1; the double

[1] After writing the above description of the "Half-Moon Lick," I referred to Prof. E. T. Cox's report of it in the "Geological Survey of Gallatin County," as published in the sixth volume of A. H. Worthen's "Report" of Illinois, and find that he has probably trusted to eye-measurement, and greatly understated the extent of this remarkable lick.

I wrote to Mr. B. Temple, who confirmed what I had written, and furnished the actual measures, as given above.

warp when twisted being about one-eighth of an inch, and the woof from one-twelfth to one-tenth of an inch in diameter. It will be observed that the twist of the warp is continuous, while that of the woof terminates at, or is lost in, the warp.

The finest specimen I have has ten threads of warp to the inch, with a woof or filling of from thirty to thirty-four. Fig. 2 is a portion of it, showing the texture, which, though exceedingly close in the filling, is plainly impressed on the clay, even showing the twist of the threads and the crimping of the cloth as bound round the vessel.

The exception referred to is a square-mesh net. The squares are one-fourth of an inch; the threads in thickness about equal to No. 6 sewing-cotton; and the knots at the corners of the meshes are very distinctly marked.

Fig. 3 represents the first piece that I found giving any idea of the union of the bandage, which in this case appears to have been by the intervention of a stick to which the threads were fastened.

Fig. 4 is a piece of the rim of a vessel where the bandage has been united by twisting.

Fig. 5 is a similar piece, showing where two pieces of cloth of different texture have been united, and the obliquity of the threads to the rim caused by the hemispherical form of the vessel.

Fig. 6 shows varieties in the pattern of the cloth.

On none of the specimens do I find impressions of cloth woven as delineated by Mr. Foster (p. 225), as cloth from the mounds of Butler and Jackson Counties, Ohio.

Most of the fragments of the large vessels are of a leaden-clay color, and, where reddened by heat, it is more on the inside than on the outside. Some specimens that I found in the woods showed signs of the action of fire on the portions projecting above the ground, from the frequent burning of the woods. Where reddened by heat, most of the markings have been thrown off.

This and other considerations lead me to doubt a burning or baking process ever having been applied to them, and I do not think it would have been possible in open fires. The unequal heat would have caused unequal expansion and contraction, and consequent cracking.

It is evident that they are composed of a cement of siliceous clay and slightly-calcined shells. None of the pieces will stand a high heat and afterward moisture. I have heated to redness large pieces, that, on fracturing, I found to contain portions of coarsely-pounded shells (flakes as large as one-fourth of an inch frequently occurring). On cooling, they were about the color of common salmon-brick; when moistened, they at once fall to pieces by the slacking of the shell-lime; and when exposed to the air they gradually waste away, the lime only slacking and causing disintegration as it absorbs moisture from the air.

If formed of cement, they must have time to harden, and for that purpose must be removed from the mould on which they were formed, to prevent cracking by contraction; and here the cloth bandage becomes a necessity. But this cloth is a costly article, requiring a great expenditure of hand-labor and time. It must not be allowed to fasten

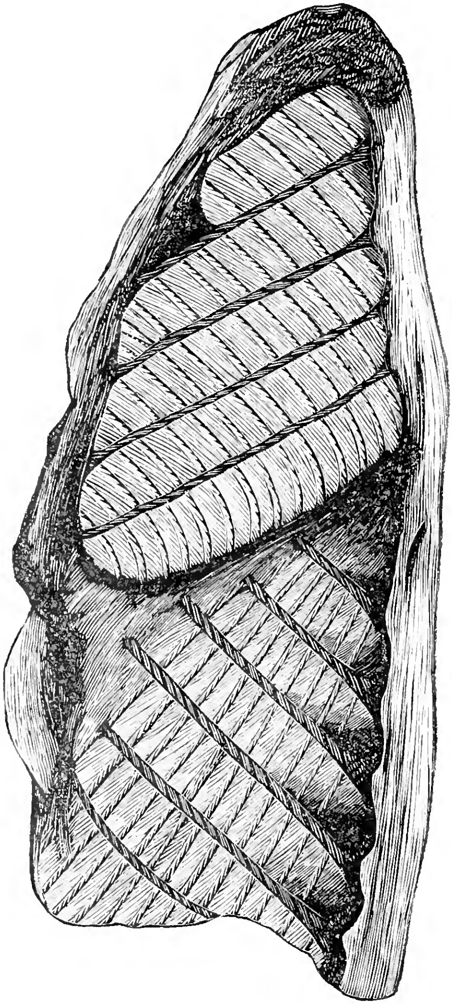


FIG. 5.

to the vessel as the cement hardens. To prevent this, a simple, natural device has been adopted. The pottery shows a laminated texture. No doubt every fresh layer of the cement has been hardly compressed on the previous one; for at hand we find the primitive tools that were used for the purpose, scattered over the site of this ancient pottery-

manufactory, in shape of flat river-pebbles, all of which are polished on the flat surface, just as the digging edges of the stone spades are by use. Cement thus compressed would be too hard to take the perfect impression of the cloth bandage; but a thin layer, or even a

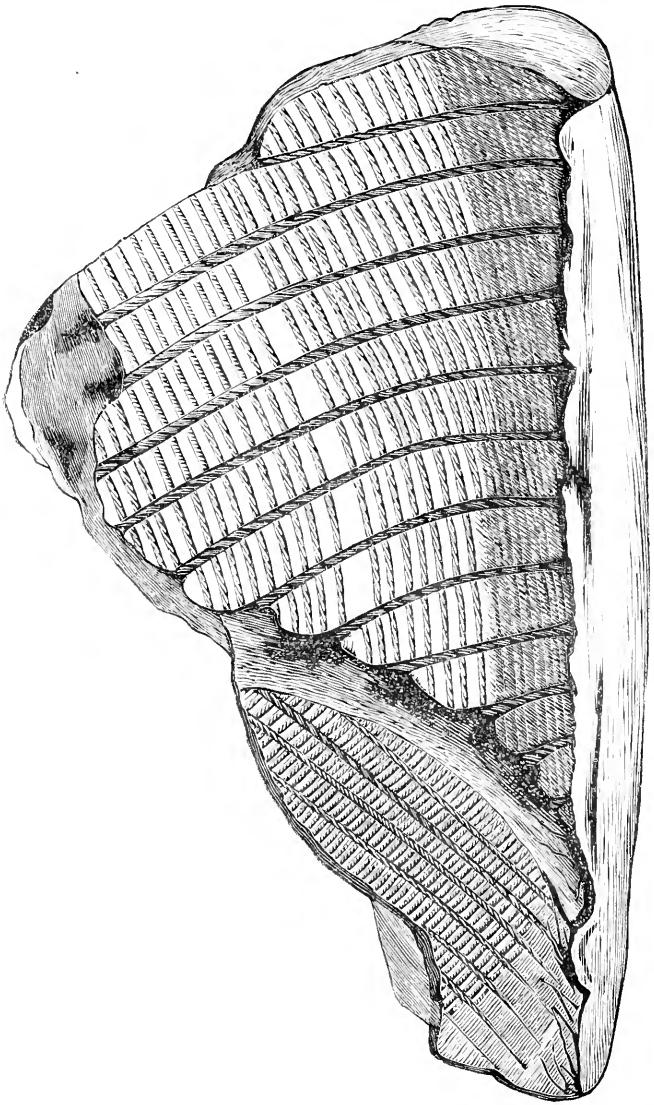


Fig. 6.

wash, of river-silt or mud would take it, and at the same time prevent the cloth adhering to the vessel; and, when required to be removed, a slight surface-moistening would accomplish the object without in-

jury to the cloth. The river-silt is sufficiently siliceous when in contact with a body of lime-cement, in process of time, to become almost as hard as the cement itself. I have succeeded in separating perfect sections of this thin surface-lamina from the underlying mass; but in no instance have I found this coating on the plain bottoms of the vessels.

And now, reader, if you have patiently and attentively followed me through these ramblings, and still believe this ancient, simple, practical people went the roundabout road you have been led to suppose to accomplish an object, with great waste of time, labor, and material, when a simpler, more natural, and direct way was open to them, and which my researches convince me they adopted, I will ask you to accompany me up the hill, not by the steep ascent, through the cemetery, but up the ravine, past the sulphur-spring. You will find it gradual and easy: in fact, part of the old, well-beaten foot-trail is now a wagon-road; but, before reaching the top, the trail leaves the road and winds among the rocks, one branch sweeping off to the left to the ancient settlement. We will take the one to the right. When you near the top of the hill, though fully a quarter of a mile from the salt-spring, keep a sharp lookout, for you may chance on a good specimen of well-marked pottery. On reaching the crown, you will be some distance west of the old town-site. Here the plough has been working destruction for many years; but you cannot take up a handful of soil without finding in it the *débris* of the old salt-pans.

You are now in a lane separating a young apple-orchard, thickly grown with clover (so thick as to cover all specimens), from freshly-ploughed cornfields, stretching far off to the south, over the grand valley of Eagle Creek.

If you can take your eyes from the charming landscape, climb with me the snake-fence into these ploughed fields, and examine the soil: you will not be likely to find any specimens worth saving, unless it be in an old fence-row, for the ploughshare has ground them and the corn has fed on them. Still, the soil is largely composed of disintegrated pottery. You may walk the furrows, examine the washes, the entire slope, to the east, to the west—you may follow its descent to the south—in every ravine, drain, or wash, you will find these remains, and you may possibly be repaid for your tramp by discovering among the wasted pottery and flakes of chert a spade, a rough and peculiarly-chipped arrow-point, or a flaked axe or chisel. But when your legs have given out, and you can walk no farther, you will have failed to find the boundaries that limit the district over which these remains are strewed. Then you will sit down and ponder in amazement, and ask, "What object could these people have had in carrying their broken pans and strewing them broadcast over so vast an extent of country, and so far from the salt-springs?" As you sit thinking, you feel the warmth of the setting sun. Its rays cast your lengthening shadow on the hill,

and that of the hill far over the valley of the Saline; from these shadows you obstruct the rays of light, and from these glimmering rays you begin to realize that these simple people, who had advanced so far as to have learned the use and value of salt, probably from the herds of mighty animals that came to lap the water of the springs, or to lick the salt-impregnated earth, had also learned that the sun dried away the water and left the salt; and as they could not take the sun down into the valley to the water, they carried the water to the sun; and here on this southern slope, which then, as it does now, caught the first rays in early morning, its noonday beams, and evening kiss, were ranged scores—probably hundreds—of these primitive vessels, in which the sun, by its direct rays and heat-laden, southern breath, was doing the work of evaporation, yet not unaided by man. Around in every direction you find evidence of this, for every stone—and there are myriads—has been through the fire. They have been heated to redness and plunged into the brine.

Now, you may say I am indulging my imagination. Well, be it so. If I am, my imagination keeps within the bounds of possibility; while yours would endow these primitive people, whose only implements or tools seem to have belonged to the rude age of stone, with a skill in handling them far beyond what we in this enlightened age possess, with all our appliances. And you do this to give a color of truth to an entirely imaginary process, not sustained by a single fact.

INSTINCT AND INTELLIGENCE.[1]

By W. K. BROOKS.

TO many persons the phenomena of instinct and intelligence in animals seem irreconcilable with any theory of the evolution of organisms through the action of natural causes, but the popular opinion upon this subject has undergone a very considerable change within the last half-century, so that the difficulty now presents itself and finds expression in a much more manageable form than would have been the case a few years since.

With regard to instinct, we can easily see that if animals of a given species are born with a constitutional tendency, or instinct, to perform a certain action under certain circumstances, this tendency may be improved and perfected by natural selection, provided favorable variations appear, and be inherited. If instinct varies in the different individuals of a species, the struggle for existence will result

[1] A lecture from a course on "Biological Theories," delivered at the Johns Hopkins University, January, 1877.

in the destruction of those in which it is imperfectly or abnormally developed, and the preservation of those individuals which exhibit any advantageous variation.

In order to place the phenomena of instinct upon the same footing, with reference to natural selection, as is held by other manifestations of life, it is only necessary to show that instincts vary, and that these variations may become hereditary.

Not a great many years ago the statement that instinct varies among animals of the same species would have been met by a flat denial, but no one at all acquainted with the subject would probably now be found to dispute it. A few examples may not be out of place, however.

The oriole now builds its hanging-nest with the pieces of string, horse-hair, yarn, and carpet-ravelings, which are to be found in abundance about houses and barns; and I have seen a nest into which three fish-lines, with their hooks and sinkers, several yards of kite-tail from a telegraph wire, and a shoe-string, were interwoven. Of course, it is not natural for the bird to use such material as this, but the odds and ends furnished by man are much better fitted to its needs than the grass and fibres used by its less civilized ancestors. This change certainly shows power to improve in accordance with changed conditions; but it may perhaps be said that it is not an example of change in an instinct, but simply in a non-hereditary habit. The fear of man, shown by almost all the smaller animals, is in many cases newly acquired, for in regions uninhabited by man it is not shown, and it is only as the animals of such regions learn, by generations of persecution, that man is highly and peculiarly dangerous, that they come to avoid him; yet this fear is truly instinctive, for it is shown by the young as well as by the adult. The testimony of travelers as to the tameness of animals in regions where they have never been persecuted, is well known. For instance, Darwin, in his "Journal" of the voyage of the Beagle, says: "This disposition is common to all the terrestrial species of the Galapagos Islands, namely, to the mocking-thrush, the finches, wrens, tyrant fly-catchers, the dove, and carrion-buzzard. All of them often approached sufficiently near to be killed with a switch, and sometimes, as I myself tried, with a cap or hat. A gun here is almost superfluous, for with the muzzle I pushed a hawk off the branch of a tree. One day, while lying down, a mocking-thrush alighted on the edge of a pitcher made of the shell of a tortoise, which I held in my hand, and began very quietly to sip the water; it allowed me to lift it from the ground, while seated on the vessel. I often tried and very nearly succeeded in catching these birds by their legs. Formerly these birds appear to have been even tamer than at present. Cowley (in the year 1684) says that 'the turtle-doves were so tame that they would often alight upon our hats and arms, so that we could take them alive, they not fearing man until

such time as some of our company did fire upon them, whereby they were rendered more shy.' Dampier also, in the same year, says that a man in a morning's walk might kill six or seven dozen of these doves. At present, although certainly very tame, they do not alight upon people's hats, nor do they suffer themselves to be killed in such large numbers. It is surprising that they have not become wilder; for these islands, during the last hundred and fifty years, have been much visited by buccaneers and whalers; and the sailors, wandering through the woods in search of tortoises, take a cruel delight in knocking down the little birds."

Darwin also says that at Terra del Fuego a certain species of goose, which is much hunted by the natives, is so wild that it is a very difficult matter to kill even one, although in the Falkland Islands, where it is not often disturbed by man, a sportsman may sometimes kill more in a day than he can carry home. This goose is not migratory; but a bird of passage, the black-necked swan, brings with it to the Falkland Islands the wisdom learned in more dangerous regions, and is very hard to obtain. Darwin ends with the following comments: "From these several facts we may, I think, conclude, first, that the wildness of birds with regard to man is a particular instinct directed against him, and not dependent on any general degree of caution arising from other sources of danger; secondly, that it is not acquired by individual birds in a short time, even when much persecuted, but in the course of successive generations it becomes hereditary. With domesticated animals we are accustomed to see new mental habits or instincts acquired, and rendered hereditary; but with animals in a state of nature it must always be most difficult to discover instances of acquired hereditary knowledge. In regard to the wildness of birds there is no way of accounting for it except as an inherited habit; comparatively few young birds, in any year, have been injured by man in England, yet all, even nestlings, are afraid of him; many individuals, on the other hand, both at the Galapagos and at the Falklands, have been pursued and injured by man, but yet have not learned a salutary fear of him." If instincts have been acquired gradually by natural selection—like modifications of structure—we should expect to find that, like other adaptations, they are in many cases more or less imperfect. We were formerly taught that instinct differs from intelligence inasmuch as it is an infallible guide and perfect in its results. If we have shown that it admits of improvement, we need not argue its imperfection; but a few examples of the failure of instinct may not be out of place. Migratory birds often return too early in the season, and perish from lack of food. The instinct which leads insects to lay their eggs upon or near food which is proper for the larvæ to which the eggs will in time give rise, although the adult insect may feed upon something quite different, is a very wonderful and beautiful

provision of Nature, but it has been shown to fail signally in some cases. Certain flies lay their eggs upon decaying animal matter, in order that the maggots may find an abundant supply of proper food; but the flies are sometimes misled by the odor of a species of arum, and lay their eggs upon the leaves of the plant. The young, of course, perish as soon as they are hatched, for they are unable to subsist upon vegetable food. The presence of a certain odor stands in relation to the existence of putrid flesh, and there is in the fly a corresponding relation between the sensation caused by this odor and a tendency to deposit her eggs. That is, the relation between a certain sensation and a certain action is in harmony with another relation between two phenomena, external to the fly; but this adjustment is not quite perfect, since the odor of the arum-plant, which is not the right odor, does what nothing but the odor of putrid meat should do.

The trap-door spider makes for its dwelling a round hole in the ground, which it lines with silk and covers with a lid or trap-door, fastened with a hinge and lying even with the ground, and fitting so exactly that it is no easy matter to find the hole, even when the animal has just been seen to enter it. To render the deception still more perfect, the top of the door is sometimes covered with living mosses and lichens, which the spider is supposed to plant in this place; the whole apparatus is very wonderfully made, and we can hardly admire sufficiently the instinct which enables the animal to construct it. This instinct may lead to a great mistake, for a close observer of the habits of this animal—J. T. Moggidge—found a nest in sandy soil, where there was no vegetation. The lid had its usual cover of moss, although this failed to answer its purpose, for the little round spot of verdure made the nest very conspicuous instead of helping to hide it. The process of fish-culture furnishes a good illustration of the imperfection of such highly-important instincts as those concerned with the perpetuation of the species. It is found that if trout, white-fish, shad, or many other species, are allowed to lay their eggs in the natural manner, a very great proportion—usually much more than half—fail to be fertilized, and of the remainder many are destroyed by crowding and lack of fresh water; many more are buried by sediment, or carried away by the current, so that only a very few develop and give rise to young fish; and many of the young are so weakened by the unfavorable conditions to which they have been exposed that they are unable to free themselves from the remains of the egg-shell, so that the number hatched is very small indeed as compared with the number of eggs. To obviate this, the male and female fish are caught just before the time at which the eggs are deposited. These are pressed out of the body of the mother, artificially fertilized, and placed in proper hatching-boxes, and in this way the number of young is increased many hundred per cent. It is no exaggeration to say that, as compared with the artificial, the natural method of propagation among

these fishes is crude and faulty in the greatest degree. Nor can it be said that this wastefulness is compensated by the great number of eggs, for the production of so many eggs by the mother involves a great expenditure of force, which might be saved by more highly-developed instincts.

In view of all the instances given, I think we may conclude that instinct is not a fixed, immutable, perfect law and guide, but an imperfect, improvable, gradually-acquired method of adjusting actions to the surrounding conditions; and therefore subject to slow perfection through the survival of the fittest variations. Let us now see whether animals possess other mental powers than the instinctive; whether they exhibit any faculty which may properly be called intelligence. No one doubts that most of our domestic animals admit of individual improvement or education, but it may be said that this improvement is due to man's intelligence, not to that of the animals themselves. There is abundant proof, however, that animals are capable of much individual improvement in a state of nature. You can't catch old birds with chaff; and a new trap partakes of the properties of a new broom. Morgan, in his book on "The American Beaver and his Works," says that beaver-houses are often found of a construction very inferior to the average; and that, according to the Indians, these are the work of young animals which have not yet completed their education. Every one who has studied the habits of cats knows how frequently they fail to raise their first litter of kittens, and a very careful observer tells me that this is true of white mice to a much greater degree.

Leroy, a writer of the seventeenth century, and a very reliable authority, says that there is a marked inferiority in the nests made by young birds, and that the best and most complicated nests are made by those species of birds whose young remain a long time in the nest, and thus have more opportunity to see how it is made.

He says that not only are the nests of young birds badly made, but that very unfit places are chosen for them, and that these defects are remedied in time when the builders have been instructed by their sense of the inconvenience they have endured. Wilson likewise claimed that there is a very perceptible inferiority in the nests of young birds. To one at all familiar with animals, the fact that each individual undergoes a process of intellectual development and self-education is so familiar that it seems strange that any one should question it; but, as the contrary statement is still occasionally met with, it seemed proper to give the above instances of improvement.

The fact that dogs dream, and under circumstances of peculiar hardship and misfortune become crazy, seems to indicate a very close similarity between their minds and ours; and no one who has seen an idiotic or half-witted dog can doubt that an ordinary dog has a mind to lose.

Dr. Kane tells us that one of the Newfoundland dogs which spent two arctic winters with him was so oppressed by the darkness and solitude of the long night, and so reduced in strength by hardship and cold, that it at last became insane, and manifested all the symptoms which were observed in some of the human beings of the party who were affected in the same way by the same causes.

Many animals, poultry for instance, have special cries for special purposes: an alarm-cry to indicate danger; a call to announce the discovery of a supply of food; a maternal "cluck" to keep the brood of chicks together; and several other cries, each of which has a meaning. These cries are undoubtedly produced and understood by the fowls instinctively, but the process by which man learns to recognize them and to understand their meaning is purely intellectual. The farmer's dog learns to distinguish and understand them as well as the farmer himself, and knows when he may be unconcerned, and when he is to go to their defense; and there is not the slightest reason to doubt that he acquires his knowledge, as man does, by a process of observation, memory, and thought. Instances of intelligence among the higher mammalia could, of course, be indefinitely multiplied, but it does not seem necessary to dwell upon the subject here. I will, however, give a few examples of what seems to be intelligence among the lower animals. I think it was Lubbock who observed a spider which wished to raise a captured wasp to a more elevated portion of the web. Finding it too heavy, it stopped its efforts and gnawed off two of the wings, and then made a second attempt. As it was still too heavy, it lightened it still further, and again tested it, and repeated the process until it had reduced its load to a manageable size. I am unable to give the authority for the following, but think the account was published in *Nature* some years since: A gentleman found a small dead bird and impaled it upon a stick, and stuck the other end of the stick into the ground near some "scavenger" beetles. The instinct which leads these insects to bury dead birds and other animals as a provision for the wants of their young is well known. In this case they soon found the bird—but how was a bird perched upon an upright stick to be buried in the ground? After some consultation they resorted to the very clever expedient of digging up the stick, and then digging a hole large enough to bury both bird and stick. Although this seems very like intelligence, it may possibly be explained as a case in which the ordinary instinctive habit of the animal accidentally fitted an exceptional demand upon it.

Many of the actions of ants, however, do not admit of any such interpretation. When two armies of ants of different species leave their homes at the same time, arrange themselves in ranks, and march to a point of meeting, and engage in battle, they exhibit, not simply proofs of concerted action, but evidences that they can arrange and plan to meet extraordinary and unusual emergencies.

Of the actions which organisms perform in order to accomplish a purpose, some, like those to which I have called your attention, are to be placed above, others below instinct. Many of the actions of plants, such as turning the leaves toward the light, the tendency of the roots to grow downward, and the closure of the flowers at night, remotely resemble instinctive actions. In some the resemblance is more perfect—the groping of tendrils for support, for instance. Prof. Gray gives the following account of this action: "When a twining stem overtops its support, the lengthening shoot is seen thrown over to one side, and usually outstretched. One might suppose that it had fallen over by its weight, but it is not generally so. If turned over, say to the north, when first observed, it will probably be found reclining to the south an hour or two later, and, an hour later again, turned northward: that is, the end of the stem sweeps round in a circle continually like the hand of a clock. It keeps on growing as it revolves; but the revolving has nothing to do with the growth, and indeed is often so rapid that several complete turns may be made before any increase in length could be observed. The time of revolving varies in different species. It also depends upon the weather—being slow or imperceptible when it is cold, and more rapid when it is warmer. Sometimes it stops when everything seems favorable, and starts again after a while. The hop, bean, and morning-glory, are as quick as any. In a sultry day, and when in full vigor, they commonly sweep round the circle in less than two hours. They move by night as well as by day. This sweeping is the cause of the twining. The stem sweeps round in order that it may reach some neighboring support; as it grows it sweeps a wider and wider space, that is, reaches farther and farther out. When it strikes against any solid body, like the stalk of a neighboring plant, it is stopped; but the portion beyond the contact is free to move as before, and, continuing to move on and to lengthen, it necessarily winds itself round the support, that is, twines." The sudden closure of the leaf of the Venus's-flytrap, as soon as it is touched by an insect, and the excitement of the glandular hairs upon its surface, still more closely resemble the instinctive actions of animals, and we here find the power to distinguish between different foreign bodies, for Darwin has shown that, although the leaf will close upon a small piece of meat, it is not excited by contact with a small piece of glass. In animals we meet with a large class of what are called reflex or automatic actions, and these are perhaps a little nearer to true instinctive actions than most of those performed by plants. Such are the actions of the various organs concerned in digestion, which are passive until the presence of food calls them into action, when they at once begin their work. A little higher are those actions which may be performed or controlled by volition, although they are usually automatic; such as winking to protect the eye from injury, and the act of throwing out the arms when in danger of fall-

ing. These are commonly spoken of as instinctive actions, but it is impossible to separate them from the class last spoken of. A little higher than the reflex actions are the truly instinctive ones, as a type of which we may take the actions of some very young chickens, experimented upon by Mr. Spalding. In a paper read before the British Association, this experimenter says: "Chickens hatched and kept in the dark for a day or two, on being placed in the light nine or ten feet from a box in which a brooding hen was concealed, after standing chirping for a minute or two, uniformly set off straight to the box, in answer to the call of the hen, which they had never seen, and never before heard. This they did, struggling through grass, and over rough ground, when not able to stand steadily on their legs. Again, a young hawk was made to fly over a hen with her first brood of chickens, then about a week old. In the twinkling of an eye most of the chickens were hid among the grass and bushes; and scarcely had the hawk touched the ground, about twelve yards from where the hen had been sitting, when she fell upon it, and would soon have killed it outright. A young turkey gave even more striking evidence. When ten days old it heard the voice of the hawk for the first time, and close beside it. Like an arrow from a bow it darted off in the opposite direction, and crouched in a corner, and remained for ten minutes motionless and dumb with fear." These examples will serve as illustrations of pure instinct, and we will pass now to actions which are superior, but obviously similar, to the instinctive ones. Actions which are frequently repeated become habitual, and habits of long standing become so firmly fixed that the actions are performed unconsciously, and, as it were, instinctively.

Most of us can remember the labor and pains which were required in order to learn to write: the comparatively easy acquisition of the art of making down-strokes, and the tendency, which we adhered to so obstinately, to form all our letters with down-strokes, and to fill in the curves and shading afterward. Any one who has watched a child writing has observed the necessity under which it labors for counting the bends to distinguish an *m* from an *n*, and the tax which an hour's writing inflicts upon all its bodily and mental powers. Constant practice soon renders writing habitual, and the necessary muscles act mechanically, so that we are able to give all our attention to the intellectual part of the process, while the writing is done without any effort or attention. A well-drilled soldier performs the proper evolution at the word of command, although he may be so preoccupied or so fatigued as to be perfectly unconscious of his actions. Such habits are remarkably persistent, especially when they are acquired early in life, and they have nothing to distinguish them from instinctive actions except that they are unconscious.

They are often performed involuntarily, and even in opposition to a previous determination. Street-car horses soon learn to stop and

start at the sound of the car-bell, and I once saw an obstinate horse, which had resisted every other means of persuasion, start at the sound of the bell and get the car fairly under way before he had time to think what he was doing.

Every one remembers the story of the old pensioner who received the command "Attention" from a by-stander while he was returning from market with his dinner in his hand. At the word of command he instantly and mechanically dropped his dinner in the mud, and took the proper position. Occasionally in man, and quite frequently in other animals, these habits of long standing are transmitted to the next generation, and, as they are then independent of individual experience, they are true instincts. Although the art of writing is not inherited, the particular style of handwriting is very often hereditary. The act of pointing or setting in dogs would be a great disadvantage to wild animals, and there is every reason to believe that it has been very recently acquired by a few breeds of domestic dogs; yet it is frequently inherited in its highly-developed form, and the transmission of a slight tendency in this direction appears to be general. The following seems to be an instance of the appearance in the second generation, as an instinct, of an acquired habit. A correspondent of *Nature* says:

"A few years ago I bought in Skye a perfectly uneducated Skye-terrier. The first accomplishment which I taught him was that of 'sitting up'—an accomplishment which he had great difficulty in acquiring. This was not owing to any stupidity on his part, for when he had once passed over this *pons asinorum* of dog-performances, he proved to be a very clever animal, and learned many other tricks with great ease. He appears never to have forgotten the pains which were taken to teach him his first trick, and to have judged therefrom that there is great merit in sitting up. Not only does he rely upon this as a last resource to move me to take him out, or not to whip him, but he judges that it must soften the heart of an India-rubber ball. Sometimes, when annoyed at his playing with this, his favorite plaything, I have placed it on a chimney-piece, and turned my attention elsewhere.

"On looking round again, I have seen my dog sitting up to the India-rubber ball, evidently hoping that it would jump down and play with him again. My dog is now the father of a family, and one of his daughters, who has never seen her father, is in the constant habit of sitting up, although she has never been taught to do so, and has never seen others sit up. She is especially given to this performance when any other dog is being scolded.

"Whether this is an instance of helping a fellow-animal, of which Mr. Darwin gives so many curious examples, or whether the dog simply hopes to avert the storm from her own head, the fact appears to me patent that this dog has inherited the impression that sitting up has some special virtue for turning away wrath."

A little higher than the habitual actions are those which are so complicated, or occur so rarely, or depend upon such delicate combinations of conditions, that they never become habitual—that is, they

are never performed without thought, although we may be able to group them into classes, and to guide our conduct by general rules or principles, either established by experience or accepted upon the authority of others. The resemblance between these actions and the instinctive ones is recognized in common speech, for we often hear it said of a person who is guided in the main, in this way, by general rules, and is often unable to assign any reason for a particular course of conduct, that he or she is a person of fine natural instincts.

The actions of the sailor, who guides his movements by the weather reports from the Government Signal-Office, without understanding or caring much about the way in which the reports are made out, are still more rational, and further removed from instinct, although they evidently fall into the series, and have much in common with those actions last mentioned. Finally, the actions of "Old Probabilities" himself belong to a still higher class, and are eminently rational.

Reviewing the ground which we have passed over, we find that living things present us with a series of more or less related actions.

First, we have the mechanical and reflex actions of plants and animals; then the instinctive action, then the hereditary habit, then the acquired habit; next the action governed by a general rule, established by experience; and finally the rational action.

Great as seems to be the difference between the two extremes of this series when considered by themselves, it is possible to pass from one to the other through a series of intermediate actions, without the necessity for any great jump in any part of the series; and it is plain that, great as are the differences between them, they all have something in common. Let us try to discover what this something is. All the actions which we have been examining are alike in this, that they are directed to the accomplishment of a purpose. The root grows downward in order that it may reach water. The leaf turns with the sun in order that it may receive a greater supply of heat. The fly-trap closes upon its prey and pours forth its secretion in order that it may be supplied with food. The vine twines in order that its long, slender stem may be supported. The digestive organs perform their various functions that the body may be nourished and its waste supplied. The eyelids close in order that the eye may be shielded from danger.

The chick instinctively seeks its mother that it may be protected and fed; and it hides from the hawk to save its life. The dog begs and the soldier goes through his manual to escape punishment, or to gain a reward or approbation, or perhaps from a combination of all these motives with still higher ones, but in any case to accomplish a purpose. The sailor watches the weather-predictions and regulates his actions accordingly, in order that his voyage may be finished as safely and quickly as possible. And the signal-officer publishes his

predictions in order that the public may be informed as to the probabilities of change.

It may be said that in the last two or three cases the purpose is intelligently appreciated, and that they are thus separated by a sharp line from the others; but this distinction gradually shades off and disappears as an action becomes habitual, and as soon as the habit becomes hereditary it may be entirely wanting.

The well-drilled soldier goes through with his evolutions without a thought as to his reasons for doing so, and nearly every middle-aged business-man of methodical habits probably recollects finding himself at his place of business on a holiday without knowing how or why he came there. One characteristic of these various actions is, then, that each has a purpose. Another is that, although the object of the action is the accomplishment of a purpose, the cause of the action is a change, external to the organism and distinct from the purpose.

The leaf of the Venus's-flytrap closes, and the digestive organs of an animal do their work, not because food is needed, but because they are excited by the presence of a foreign body. The dog points because he scents a particular odor, not because he wishes to do his duty. The soldier assumes his position because he hears the word of command, etc. The actions which are the subject of our present lecture stand, then, in a double relationship. They are excited by certain external changes, and they have for their object the accomplishment of a purpose. Herbert Spencer has expressed this dual relationship in a simple formula. According to him, these and all other peculiarly vital actions consist in "the adjustment of internal relations to external relations." This is not very lucid when stated abstractly, but perhaps an example will help to make it clear. If I kick a stone, I may move it a greater or less distance, and set up some slight molecular change within it, and hurt my foot, perhaps. If I kick a dead dog, the result is the same; but, if the dog is alive, I shall find that all these results follow, and something more. The molecular change in the nerves of the dog gives rise to or excites a series of actions adapted to meet my attack and to prevent further injury. There is a relation, external to the dog, between the kick and a disposition to do him further violence; and there is an internal relation in the dog between the sensation caused by the blow and a desire to escape the violence which is to follow; and whether he crouches and supplicates, or puts his tail between his legs and runs, or returns my attack, he simply adjusts internal relations to external relations. There is a relation between a downward direction and the presence of water in the ground, and to this relation the roots of the plant respond.

There is a relation between the presence of a foreign body in the stomach and food to be digested; and accordingly, when the stomach is excited by the sensation of contact with a foreign body, it be-

gins its work—that is, there is an adjustment between the internal relation of a certain sensation to the digestive process and the external relation between the presence of foreign matter in the stomach and food.

There is a relation between the sudden approach of a body toward the eye and danger to that organ, and to this relation the nerves and muscles are adjusted. There is a relation between a peculiar "cluck" and the presence of the mother-hen, and to this relation the chick responds. There grows up in the mind of the soldier a connection between the word "attention" and a particular attitude, and when he feels the sensation caused by the command, he at once, and unconsciously, performs the muscular movements necessary to assume that position; that is, there is an adjustment between the internal relation of a certain sensation to certain muscular movements and the external relation of a certain command to the necessity for assuming a given position. The sailor learns that there is a relation between certain signals and stormy weather, and to this relation his actions are adjusted. Finally, General Meyer finds that there is a relation between low barometric pressure in certain parts of the country and a liability to storms in other regions, and to this external relation he adjusts his actions.

The kind of external change to which an organism may respond of course varies greatly in different cases, both in constancy and complexity. The Venus's-flytrap is adjusted only to relations between objects on the surface of the leaf and in contact with it, but an animal with even rudimentary organs of sense may respond to changes which occur at a distance. Even the simple capacity to distinguish light from darkness is enough to enable an animal to perceive a distant body between it and the sun, and to adjust its actions accordingly.

As we ascend to creatures having more developed eyes, we find an increase in the sphere of surrounding space throughout which external relations can establish corresponding internal relations. A slight convexity of the epidermic layer lying over the sensitive tract first serves, by concentrating the rays, to render appreciable less marked variations in the quantity of light, and thus brings into view the same bodies at a greater distance, and smaller or less opaque bodies at the same distance. From this point upward, through the various types of aquatic creatures to the higher air-breathing creatures, we trace, under various forms and modifications, a complicated visual apparatus and a widening space through which the correspondence extends. It is needless to go into details. Hypotheses and illustrations aside, it is obvious that from the polyp, which does not stir till touched, up to the telescopic-eyed vulture or the far-sighted Bushman, one aspect of progressing life is the greater and greater remoteness at which visible relations in the environment produce adapted relations in the organism. The extension of the correspondence in space does not end

with the perfecting of the senses. In creatures of comparatively advanced organization there arise powers of adjusting inner relations to outer relations that are far too remote for direct perception. The motions by which a carrier-pigeon finds its way home, though taken a hundred miles away, cannot be guided by sight, smell, or hearing, in their direct and simple forms. Chased animals, that make their way across the country to places of refuge out of view, are obviously led by combinations of past and present impressions which enable them to transcend the sphere of sense. And thus also must it be with creatures which annually migrate to other lands.

In man, this secondary process of extension is carried still further. Though the correspondences he effects by immediate perception have a narrower range than those of some inferior creatures, and though in that species of indirect adjustment just exemplified he is behind sundry wild and domesticated animals, yet, by still more indirect means, he adjusts internal relations to external relations that are immensely beyond the appreciation of lower beings. By combining his own perceptions with the perceptions of others as registered in maps, he can reach special places lying thousands of miles away over the earth's surface. A ship, guided by compass, and stars, and chronometer, brings him from the antipodes information by which his purchases here are adapted to prices there. From the characters of exposed strata he infers the presence of coal below, and thereupon adjusts the sequences of his actions to coexistences a thousand feet underneath. Nor is the environment through which his correspondences reach limited to the surface and the substance of the earth. It stretches into the surrounding sphere of infinity. It was extended to the moon when the Chaldeans discovered how to predict eclipses; to the sun and nearer planets when the Copernican system was established; to the remoter planets when an improved telescope disclosed one, and calculation fixed the position of the other; to the stars when their parallax and proper motion were measured; and, in a vague way, even to the nebulæ when their composition and forms of structure were ascertained. At first sight, no two things could seem to have less in common than the tendency of a sprouting potato to grow toward the light, and the preparations made by human beings for such a rare, and distant, and complicated event as a transit of Venus; yet each is, objectively considered, an adjustment of internal relations to external relations, and the two phenomena are so well connected by intermediate forms that there can be no doubt of their relationship.

Physiologists are gradually proving the statement that these and all other vital changes are, in ultimate analysis, changes in the protoplasm of the body, and that they are not brought about by any peculiar vital force, but are the direct outcome of the physical and chemical structure of the protoplasm itself; so that vital changes, considered

simply as changes, must not be regarded as peculiar, and fundamentally unlike the changes of inorganic matter.

Vital changes cannot, however, be regarded as changes simply standing by themselves, for, if we overlook their adjustment to the accomplishment of a purpose, we omit their most essential characteristic.

In so far as the contraction of a muscle is simply a change, it is without doubt purely physical; but in the adjustment of this change to a relation between external changes, in its adaptation to a purpose, we have something which has no parallel except in living things, and perhaps some of man's contrivances, such as the automatic governor of the steam-engine. Living things are distinguished from those which have not life by their adjustment, and life consists in this adjustment. Small as this difference seems when stated abstractly, and unimportant as it appears to be when we contrast such an organism as an amœba, with its simple and almost mechanical power of retracting its pseudopodia upon irritation, and such a highly-complex and changeable inorganic being as the ocean, yet, considered not in itself but in its adjustment to external relations, this power in the amœba separates it very widely from all inorganic forms of existence, and connects it with the highest manifestations of life; for the series of adjustments of which that of the amœba is one of the simplest may be traced almost without break up to the most rational actions of man. A vorticella contracts and folds down its circlet of cilia when touched, because there is a connection between violent contact and the presence of danger; and this recognition of a connection between the changes of the external world is knowledge of the order of Nature, and this, in its higher form, is experience, and experience implies memory, and memory and experience are forms of consciousness. Thus we are able to understand the meaning of such expressions as that of Haeckel, that living things are distinguished from the not living by the possession of memory. It seems best to restrict the use of such purely subjective terms as *memory* and *experience* to the higher forms of conscious life, but we must not overlook the fact that the existence of an adjustment between internal and external relations implies something fundamentally like the memory of higher animals.

Finally, I wish to call attention to the fact that natural selection is constantly acting through the law of the survival of the fittest, in such a way as to bring each organism into more and more perfect harmony with its environment; that is, it is constantly bringing about a more and more exact, definite, and perfect adjustment between external and internal relations. If this adjustment constitutes vitality, and if natural selection furnishes an explanation of the manner in which the adjustment has been brought about, have we not, in the law of natural selection, an explanation of the origin of life?—not of course of the origin of the matter of life, nor of the changes of

which life is made up, nor of the production of living beings, but of the origin of those attributes by which living things are especially characterized, and in which they differ from all other forms of existence.

SCIENCE AND WAR.

By H. BADEN PRITCHARD.

RECENT wars have had particular interest for the man of science. If we go back some fifteen or twenty years and consider the different wars which have unfortunately occurred since that time, we shall find connected with each one of them certain features which undoubtedly mark progress in the art of killing and wounding. Some argue—and on very good grounds, no doubt—that the more sharp and terrible warfare is made, the more speedily must it come to an end, and hence look with favor upon the means taken every day to render weapons more destructive and the soldier more cunning in his dangerous trade. We do not propose to discuss this argument, nor to enter at all into any comparison between the wars of our forefathers and those of to-day, but at a crisis like the present we need hardly apologize for bringing before our readers some points illustrating the marked influence of science upon modern warfare.

Starting from the close of the Crimean War, the first in which the electric telegraph was employed, we find ample examples of the assistance furnished to the soldier by scientific research. One instance taken from the war of 1858 is especially interesting. The Austrians held Venice at the time, it may be remembered, and, to protect the harbor, torpedoes were laid down. The torpedoes were fired by electricity, and contained gun-cotton, this being the first instance on record of the employment of electric torpedoes and of the newly-invented nitro-compounds. Nor was this all. The torpedo system devised at Venice by the Austrian engineers had yet another point of scientific interest. A camera-obscura was built overlooking the harbor, and upon the white table of this instrument were reflected the waters of Venice. As the torpedoes were sunk one by one a sentinel in the camera noted the place of their disappearance with a pencil, giving each torpedo a consecutive number. A row-boat in the harbor described a circle around the sunken torpedo, indicating the zone of its destructive power, and the sentinel again, with his pencil, made a corresponding ring upon the camera-table. In the end, therefore, while the harbor itself was apparently free from all obstruction, a very effective means of torpedo-defense was established, the key of which was only to be found in the camera-obscura. The sentinel here had wires in connection with every torpedo, and was in a position to fire

any one as soon as he observed—by means of the camera—the presence of a hostile vessel within the limits of any of the circles marked upon his white table.

In the American War of 1860, the electric torpedo, invented but two years before, played a most conspicuous *rôle*, and formed indeed, with the use of big guns and monitor iron-clads, one of the most important features of the struggle, at any rate from a scientific point of view. The war of 1866, when the Austrians suffered such a terrible defeat at the hands of the Prussians, will long be remembered as a combat between the old muzzle-loading rifle and the breech-loader, in which the latter was victorious. The Franco-German struggle of 1870, again, though marked by the employment of no special arm, if we except the mitrailleuse, was assisted by important applications of science; to wit, the reproduction, by means of photo-lithography, of the French ordnance maps and plans, which were distributed in thousands throughout the German army, and the establishment in France of *la poste aérienne* to communicate with the besieged garrison of Paris. The regularity with which the mails left Paris *par ballon monté* must still be fresh in the memories of our readers, the publication of correspondence from the French capital being maintained in our journals during the whole period of the investment. From September 23d to January 28th, when Paris was practically cut off from the rest of the republic, no less than sixty-four balloons left the city with passengers, mails, and pigeons, and of these only three were lost, while five were captured. The return-post by "homing pigeons" was hardly so regular, but nevertheless half the number of dispatches given in by correspondents at Tours and elsewhere, or in other words 100,000 messages, were by the unflagging energy of the postal authorities carried into the beleaguered capital. The dispatches, most of them as brief as telegrams, were distinctly printed in broad sheets and photographed by the aid of a micro-camera; impressions upon thin, transparent films were then taken and rolled in a quill attached to the tail of the winged messenger which was to bear them into Paris. Arrived at their destination, the tiny photographic films were enlarged again by the camera, and the dispatches, being once more legible, were distributed to the various addresses.

The present Russo-Turkish War cannot well be less interesting than those that have so recently preceded it, and we may especially point out two directions in which fresh examples of scientific warfare will probably manifest themselves—in connection, namely, with the cavalry pioneer and the Whitehead torpedo. Both of these will probably be seen in warfare for the first time, and before many days are past we may hear of their doings in action.

The cavalry pioneer must not be confounded with the Prussian Uhlan who played so conspicuous a part in the last war. The ubiquitous Uhlan, terrible as he was, did not work the injury which some of

the Cossacks will have it in their power to inflict if accoutred as pioneers. These are selected from the smartest and most daring troopers, lightly armed and well mounted. In a belt round their waists they carry a few pounds of gun-cotton or dynamite, and with this highly-destructive explosive they may work incalculable harm. A small charge of gun-cotton placed simply upon a rail and fired with a fuse suffices to blow several feet of the iron to a distance of many yards, thus rendering the railway unserviceable on the instant. A trooper may dismount, place a charge at the base of a telegraph pole, fire it, and be in his saddle again within sixty seconds. Wires may thus be cut and communication stopped in the heart of an enemy's country by fearless riders, who have but to draw rein for an instant to effect the mischief, while lines of railway in the neighborhood are entirely at their mercy. Even light bridges and well-built stockades may be thrown down by the violent detonation of compressed gun-cotton, and forest-roads considerably obstructed by trees thrown across, which are never so rapidly felled as when a small charge of this explosive is fired at their roots.

The influence of the Whitehead torpedo, of which we have heard so much of late, will likewise be felt for the first time during the present war. An implement so ingenious in its character that, as Lord Charles Beresford the other day happily remarked, it can do almost anything but talk, is in the possession of both belligerents, and will doubtless be heard of ere long on the Danube and in the Black Sea. These torpedoes are manufactured at Fiume on the Mediterranean, and, like Krupp guns, are to be purchased by any one who chooses to pay for them.

The British Government manufactures its own Whitehead torpedoes in this country, having paid several thousand pounds for the privilege. The machinery inside this torpedo is still a secret, which is strictly maintained by our Government, but the principle of the invention is well known. It is a long, cigar-shaped machine measuring a dozen feet and upward. In the head is a charge of some violent explosive, such as gun-cotton, or dynamite, which explodes as soon as the torpedo strikes an obstacle. The motive power is compressed air, which is forced into the machine by powerful air-pumps, immediately before the torpedo is discharged into the sea, no less than 600 pounds on the square inch being the pressure exerted. The Whitehead is shot from a tube, and moves through the water as straight as a dart, the compressed air working upon a screw in the tail of the machine. The delicate machinery permits the torpedo to swim at any depth below the surface that may be desirable, and it flies straight in the direction it is aimed, at a speed of something like twenty miles an hour. If it fails to strike the foe, then the intelligent apparatus at once rises to the surface, becoming innocuous as it does so, and may in this condition be captured without difficulty.

A torpedo of this sort striking the sides of an iron-clad would almost infallibly send her to the bottom, and although it has been proved that a network or crinoline around the ship is capable of retarding the progress of a "fish" of this nature, and exploding the same harmlessly in its toils, it is obviously a very difficult matter thus to protect one's craft. Against heavy torpedoes, indeed, there seems no way of defense at all (the Whitehead generally carries a charge of seventy or eighty pounds, but moored torpedoes may contain a 500-pound charge), and therefore Turkish vessels will have to give Russian ports a wide berth. All must remember how the magnificent fleet of the French was kept at bay by the torpedoes of the Germans in the North Sea in 1870, and the Black Sea ports are no doubt similarly protected. So demoralizing is the dread of the torpedo with sailors apparently, that they will dare anything rather than venture into waters which conceal these cruel foes.

At no other time has there been so much want of unanimity among the great powers of Europe on the subject of ordnance. There are to be found at the present moment cannon of a dozen different descriptions in the gun-parks of European nations, differing from each other not only in respect to their construction, but in the metal of which they are made. So far as small-arms are concerned, we know there is but one opinion; some nations prefer one breech-loader to another, but all agree in the employment of breech-loaders. In the case of cannon, however, it is different. Germany relies upon breech-loading ordnance, while Great Britain has forsaken the system and gone back to muzzle-loaders; Austria makes her guns of bronze, Germany of steel, Russia favors steel and brass, America cast-iron, while England has cannon of steel encompassed with iron, and France weapons of iron girt with steel.

The balance of favor is beyond question with the breech-loader at the present moment. All the new artillery of the Russians and the Turks is of this kind, while the field-guns both of the Germans and Austrians are upon the same system. France has done nothing lately for the regeneration of its ordnance, and there remain but Great Britain and Italy to represent muzzle-loading artillery. But Italy, although she has adopted the British system for very heavy guns, is by no means a confirmed believer in it, and will doubtless hesitate before following our example very far, beset, as she is, with neighbors armed with breech-loaders.

Of all the powers, it is, curiously enough, steady-going Austria which has taken the boldest and most independent course in the matter of artillery. It was but at the end of 1875 that the Austrian War-Office decided to adopt the Uchatius cannon for field-artillery, and yet at this moment every artillery regiment of the vast Austro-Hungarian army is armed with the new weapon. Within eighteen months no less than 2,000 of these cannon have been cast and finished, and now

the Vienna arsenal is engaged in the manufacture of heavy guns of the same character. Never was a more energetic step taken. A new cannon of some sort was held to be absolutely necessary to uphold the prestige of the army, and a commission having been intrusted with the selection of an arm, pronounced without delay in favor of the scheme brought forward by General von Uchatius. In October, 1874, the first round was fired from a Uchatius gun, and a twelvemonth afterward the sweeping reform which was to introduce an entirely new artillery throughout the Austrian service was decided upon. Government sanctioned an expenditure of £1,800,000 to be spent in two years, and General von Uchatius was directed to give all the assistance in his power toward the fulfillment of the design.

The Uchatius gun is made of so-called steel-bronze. Chilled bronze would be a better name, since Uchatius casts his metal in a chilled, or metal mould, in the same manner, pretty well, as Sir William Palliser produces his famous chilled projectiles. Bronze, as everybody knows, has been a favorite metal with gun-founders from the earliest days, and in the East, especially, magnificent castings of this nature have been produced. About ninety per cent. of copper and ten of tin is the mixture commonly employed in making ordinary bronze, and eight per cent. of tin is the proportion preferred by Uchatius. The difficulty in casting bronze, as those who have any experience know full well, is that of securing homogeneity, soft particles of tin becoming isolated in the mass, and giving rise to the defect known as "tin-pitting." Whether we have lost the secret of bronze-casting, or whether in former times they were more skillful at the work, certain it is that founders of the present day are unable to secure so uniform an alloy as formerly. This was very apparent when some eight or ten years ago our own Government adopted, for a brief time, bronze artillery. The addition of a small percentage of phosphorus did not mend matters, and the highest authorities on the subject were at a loss to suggest an effective remedy. Our bronze guns, too, had another defect which could not be overcome. After firing the bore became affected, and the weapon, as it was termed, "drooped at the muzzle." These were the two defects indeed that led mainly to the abandonment of the bronze gun in this country, and they are, too, the difficulties which General von Uchatius appears to have overcome. He has got rid of "tin-pitting," and his guns do not "droop at the muzzle."

Uchatius found that by subjecting the alloy in a liquid form to considerable pressure, he was enabled to secure a perfectly homogeneous mass, a result which was also furnished, he discovered, when he had gone a step further, if the molten metal was rapidly cooled. Steel-bronze is apparently made much in the same way as the toughened glass of which we have heard so much lately. After being cast in a mould, the alloy is thrust into a reservoir of oil, heated to a high temperature, so that the metal suddenly cools, but only down to a cer-

tain point. Then the casting is withdrawn and allowed to get cold more gradually. A regular and crystalline structure is in this way produced, which has none of the defects of ordinary bronze. It is a moot point whether phosphorus enters into the composition at all. Chemists tell us they can find no trace of it, but this is no absolute proof that a small percentage of the element was not originally contained in the alloy, being burned out after it had done its work of harmonizing the two metals. The inventor is rather reticent on the point, but in any case it is very certain that he produces a uniform and homogeneous alloy of a hard, crystalline nature.

One other expedient Uchatius has recourse to in making his cannon. When he has cast his gun and chilled it, he proceeds to dilate the bore. Wedges of steel, shaped in the form of cones, are forced into the tube of the gun one after another, until the calibre of the weapon has been increased by something like seven or eight per cent. This expansion or dilation of the tube has not only the effect of hardening or steeling the core, but also of rendering the gun more elastic and capable of resisting more effectually the strain put upon it at the moment of firing. The gun, after this process, is in a state of elastic tension, and it is said that there is a pressure from without, inward, equal to that which was exerted to dilate the gun in the first instance; and that this is actually the case can scarcely be doubted, since it is a fact that a section of the gun, before being quite severed, will tear itself loose with considerable violence, and will be found on separation to have partially returned to its former calibre.

So far as practical trials have been conducted with the weapon, the Austrian Government have every reason to be satisfied with the Uchatius gun, which compares favorably with the Krupp steel cannon in the matter of accuracy and durability; while, as regards its cost, it is far cheaper than any other rifled ordnance. A steel field-piece costs upward of £100, even when not protected with rings, while the iron-steel weapon, manufactured in this country, costs about £70 sterling; the steel-bronze cannon of General von Uchatius, on the other hand, are made for £35 apiece.

In construction, the Austrian gun is so similar to that of Herr Krupp, of Essen, that the latter claimed compensation for an infringement of his patent when the manufacture of the Uchatius gun was first commenced. The Essen works, our readers may know, supply not only Germany with steel breech-loaders, but have provided the present belligerents with all their modern artillery. Russia has still many brass cannon on hand, and Turkey a goodly number of Armstrongs, but both powers mainly depend upon their steel Krupps. These stood the German army in such good stead during the last war that their reputation is firmly established. They are of crucible steel, and the breech, instead of being upon a hinge, or in the form of a block, moves round in a D-shaped socket, the escape of gas being further prevented by rings of phosphor-copper.

The manner in which the ordnance of this country is constructed is sufficiently familiar to our readers. A tube of steel is encompassed by jackets of wrought-iron, and in this way the toughness of the latter is combined with the hardness of the former. All our guns, as we have said, load at the muzzle, while those of Russia, Germany, Austro-Hungary, and Turkey, are breech-loaders. Italy, in the case of the 100-ton guns with which she intends to arm her two stupendous turret-vessels, the Duilio and Dandolo, has adopted our method of construction, except that she employs smooth, instead of studded, projectiles. With the employment of a gas-check at the base of the shot to prevent windage and so secure the full force of the exploding charge, the use of studs in a shot appears to be unnecessary, sufficient spin being imparted to the projectile by the soft metal of the gas-check before named, which causes the shot to rotate after the manner of a Snider bullet. So satisfactory, indeed, were the Italian trials of these projectiles last year that it is by no means improbable that we, too, may give up the use of studded shot.

As to the comparative value of breech-loaders and muzzle-loaders, we shall not offer an opinion. No doubt a muzzle-loader is the stronger weapon, because its breech is solid; but our cousins, the Germans, urge very justly that, since their guns do not burst, they are quite strong enough. Advocates of the muzzle-loading system argue again that their weapon is more simple in construction, and for this reason is to be preferred; but on the other hand the sponging and loading of a gun is more easy to effect if it opens at the breech. Indeed, in the case of very heavy guns located in a casemate or on board ship, the Germans reproach us with the assertion that we must needs have recourse to all sorts of complicated and awkward machinery in loading, while in their case a simple pulley or crane is all that is necessary. Either, say they, we must expose our gunners through the open port when loading, or, as in the case of the Thunderer, rely blindly on hydraulic apparatus to work the guns for us. So stands the question: perhaps the present war will bring us a solution of it.—*Nature.*

THE LABOR-QUESTION.

By R. G. ECCLES.

In sociology, the "personal equation," if not eliminated, distorts men's view of Nature's workings more than in any other department of thought. Despite this, nowhere else do they cling so tenaciously to this distorting factor. Shallow conclusions, based upon traditional notions of right and wrong, tinctured with the bias of class or education, is the sum total of the majority of attempts at making

clear this vexing but important subject. Scientific methods are unthought of, and scientific conclusions either ignored or denounced as cold, hard, and unsympathetic. They never trouble themselves about ascertaining what it is *possible to do under the circumstances*, but, without a minute's consideration, set up their Utopian standards of right, and at once proceed to bend everything in that direction. Should they deem it right to reverse the course of the Mississippi, we might almost expect to see them undertake the impossible task, careless of all disastrous consequences. They have wasted power by asking what *ought* to be done, instead of inquiring what *can* be done.

If ever this problem receives an accurate solution, it will come from viewing it physically rather than morally. As the bone and sinew of man is the stored energy of sunbeams, so property or capital is the same energy re-stored after being unlocked as work. As the former is the potential energy of physical life, so the latter is the potential energy of social life. Any attempt at viewing the matter by ignoring this law of the conservation of energy, which is at the foundation of social order, can only result in false opinions and lead to dangerous measures.[1] When men were savages, and bone and sinew ruled, he who had most physical power was chief. Now, a vaster magazine of energy is accumulated in capital, and whoever has most of it rules. This is but a plain statement of fact. The power is there lodged by the very constitution of society, and no attempts at realizing the dream of communism can wrest it away. What can the man of muscle do?

In early stages of human development, the accumulation of bodily vigor and strength was the main object of life. Natural and sexual selection conspired to pick the strongest, best-formed specimens, while driving the weak and worthless to the wall. Strategy soon competed with strength, and, when victor, intellect was picked with it. From among all the strategic devices of intellect property was selected as the fittest, and society became a necessity for its protection. As at first men found that such life as they sought could only exist when bodily waste was balanced or overbalanced by accumulation, so now we cannot long maintain physical health if nutrition fails to keep pace with waste. Some form of phthisis may take hold of us and increase the waste beyond the normal, or our supply of food may be withheld, and we die of inanition. Social life is subject to two just such sets of dangers. In a machine we have friction and interference answering to similar ideas. These must each be brought to the minimum if we would have things work smoothly.

Are working-men, as a class, frugal and provident? Do they curb self-gratification, and make present sacrifice for future advantage? How many mechanics or day-laborers calculate their annual waste of means on such unnecessary articles as tea, coffee, tobacco,

[1] When this was penned the writer did not suspect it would be so quickly verified.

beer, whiskey, etc.? How many, instead of selecting plain, wholesome, cheap food, spend their extra dollars on pastry, *rare* fruits and vegetables, etc.? The business done in this line by the grocers and bakers of the lower wards of New York will answer this. I have eaten at the tables of rich and poor in many States, and my experience teaches me that, as a rule, the well-to-do mechanic lives better than many merchants, bankers, and professional men, as long as his wages hold out. The same prodigality is manifested in dress and ornament. They will make any sacrifice to ape the rich or vie with each other. Servant-girls often dress better than their mistresses. Who will calculate the dollars wasted by that mechanic's family, before sickness or accident drove him to the poor-house? How much did he throw away on rent, that he might live in a better house than he was well able to afford? How many dollars were spent on theatres, balls, sociables, fairs, or excursions, that might have been saved? How much did superstition extort from him? These are a few of the many avenues through which his hard-earned wages escaped. Add to these the physician's bills, for attending to himself and family when overwork and uncleanliness brought on sickness; and, last though not least, consider the number of mouths he is himself the cause of having to fill, and the number of backs to clothe. If his income had overbalanced this expenditure, when the crisis arrived he would have been safe. With how many of our present paupers and tramps was this the case? Are the careful to be forced to bear the load of the careless? Self-restraint is more important to the poor man than legislation. This will give him a fitness for the battle of life, while that but unmans and effeminates him.

Again, are these men now out of employment the best types of laborers or mechanics, and the most trusty and efficient servants their employers had? Are they the honest, careful, thoughtful working-men who labored most earnestly for their employers' interests? Are those who have been retained the stupid and dishonest?—the unprofitable servants? Are they—but why proceed? The case is only too clear against the unemployed, as a class. Of course, there are exceptions. Unavoidable circumstances have doubtless thrown adrift the worthy. When a crisis comes, employers will retain those who have labored most faithfully and honestly for their interest. All others must lose employment. The improvident at once become paupers, demanding a living from their already heavily-burdened but careful fellow-workmen. If, during the age of muscle, lazy, puny men with diseased bodies, brought on by excess and vice, had demanded of the stalwart and vigorous that they must carry them on their backs, even though at their own peril, what could have been thought of them?

An army of unemployed men is clamoring for work, and the sympathetic urge their claims. "Fate is dealing hard with them," say

they; "can we not alleviate their distress?" They would invoke state aid in behalf of these social failures, and thus increase the burdens upon the employed, forgetting that "the last straw breaks the camel's back." They would increase the number of officials, and lose thousands of dollars of the people's money by theft, while only tens or hundreds were bestowed as charity. They forget that the poor millions who are the consumers are the real tax-payers. All experience has shown that only abortive effort and theft can be hoped for when the state interferes. It is already overloaded with such work, and its officers are men subject to temptation where cash is concerned. A change of these has been advocated, but this would only be a change of thieves. No one class has a monopoly of morality. There are moral and immoral men in all classes; and, unfortunately, men of light specific gravity are more apt to swim in the sea of politics than their more solid fellows. Shall we, then, resort to an indiscriminate bestowal of alms? Statistics have again and again shown that, in the direct ratio of alms-giving, there is an increase of pauperism and crime. The easier you make the pauper's life, the more of that restraint you remove which now hinders many from choosing pauperism as a profession. If you have money to spend upon them, demand an equivalent in work of some kind for every cent bestowed. This leaves them with a spark of manly feeling, and satisfies your desire to relieve their wants. I have seen philanthropic men and women refuse to purchase a cane, toy, or newspaper, from a really suffering and needy person in the street, because they either did not want the article offered or would not be troubled with it; and I have then seen them go a few steps and drop as much money as would have made the purchase into the hat of a professional beggar, who was less worthy and less needy. It was hard to escape the conclusion that the sympathetic feeling which could only be satisfied by giving without requiring aught in return was here tinctured with the unhallowed self-righteousness of the Pharisee.

In these unemployed workmen we have a vast amount of energy wasting itself in uselessness or crime. In the bank-vaults lie unused large stores of the potential energy of society. Rich and poor are suffering from the inactivity. What is the cause of this? The capitalists will make no new investments, as they will not pay. Business is stagnant. People refuse to purchase. Such is the general cry, and over-production takes the blame. Over-production of what? How can an over-production of wheat and potatoes produce an over-production of everything else? How happens it that all the industries appeared to collapse together? Was there over-production in all? Has each person in these United States got all the clothing and articles of comfort and luxury he can possibly desire? How can over-production be chargeable with this state of affairs, when, by a little thought upon the matter, we might see that the evidence points to

the fact that every increase of goods brings a corresponding increased demand for such goods?

If there is one thing more than another working-men long for, it is high wages. To keep up their pay they unite in trades'-unions and analogous combinations. The employer wages war against this effort. While the former would demand all the profit of his labor, leaving the latter nothing for his pains, he in turn would like to retain it all for himself. If these were the sole factors of this battle, wages would steadily ascend, the balance of force ranging upward. Unfortunately (?) for the workman, this is not the case. His own unconscious efforts to pull wages down outweigh his conscious efforts to keep them up. Can he not see that every time he deserts a dear dealer to buy from a cheap one he is thoughtlessly creating a tendency to lower the wages of all who take part in the manufacture of such articles? This eventually, and through a variety of channels, works around to his own. This move on his part likewise creates a necessity for dishonesty and adulteration, which still further reacts against him. His employer, on the other hand, does more toward keeping up wages by seeking dear markets for his goods than his conscious efforts amount to in pulling them down. As the heaviest strain on the produce of the workman is the downward one, since all consumers take part in it, *wages must fall.* All the world clamors for cheap goods. Eventually a point of stable equilibrium must be reached, where very low wages precede very cheap goods. As capitalists, studying the cost of production, hold on to goods, refusing to sell at a sacrifice, their sales descend or cease, and wages are thrown down first. Could working-men be made to realize the fact that high wages mean correspondingly high food, clothing, fuel, rent, with all else he would purchase, while low wages mean the opposite, I think they would agree with me in saying that the amount received per diem for their work was of secondary importance. Some laborers must take the shrinkage in advance of others.

That there are more goods in the American market than is at present demanded, under existing conditions, is a certainty. But if over-production has glutted one market, why not seek another? Why stop mills and factories? Why turn laboring-men into the street? Is there no channel of least resistance for business to travel in? An over-production of goods is an over-production of wealth. Has the nation more wealth and comfort than it can manage or knows what to do with? The thing is perfectly absurd. When railroads came they brought an over-supply of accommodation for stage-coach travelers, but this extra amount of room found a use for itself in making travel cheaper and more comfortable, so that immensely more people traveled. Every labor-saving machine has done the same for the articles it produces. But suppose the price of travel had kept up, and the comforts remained the same, while the means of carrying

passengers had rapidly increased, what would have occurred? Suppose the cotton machinery had turned into the market millions of yards of cotton, where hundreds answered before (as is actually the case), and the manufacturers had charged the old prices, what would have happened? It is obvious that in the first case not one extra traveler would have gone from home, and the much-needed railroads would have been a nuisance; while, in the second, the manufacturers would have been deluged with their own stock, been compelled to close their factories and howl "Over-production!" *Whatever arrests the descent of prices, entails upon society just such a state of affairs as we are passing through.* It stops wide distribution, as the owners of such goods are unable to cope with the traders of foreign markets. Protectionists aid in this part of the trouble. It accumulates a heavier supply than is demanded in the home-market. It overwhelms factories with their own goods, and drowns the manufacturer in bankruptcy, unless he stops work. It turns worthy, as well as unworthy, working-men adrift. It brings on all the horrors so piteously complained of. What can avert such consequences? There are, doubtless, factors in this problem unnoticed here, but this to me appears to be the main one. Allow wages to descend steadily, as the market demands, instead of holding them up till a crisis is reached. When crises come, they hurl them down like an avalanche far below the true level at which they should rest. Let the machinery of society have free, unimpeded action. Teach laborers to give way to the inevitable, without clogging the wheels by "strikes." They must learn to give in to the decrees of Fate without a murmur. They frighten themselves with a bugbear of starvation from low wages, and bring in a real bear with their acts. "O ye of little faith!" Will they never learn that eight hours' work at one dollar, with goods at half-price, is far better than four hours' work at the same, with goods at full price? Trades'-unions are waging war against natural law. Wages must come down! Profits must decrease! It is absolutely impossible to keep these up and have business proceed. If not satisfied with the pay offered by one employer, seek another. Unions, when other than a council of working-men aiming at the common good, are positive evils. Society must learn to frown down every interference on their part with the workings of trade, or we will be continually subject to recurrences of business stagnation and violence. They thwart their own purposes and entail the very miseries they profess to cure. Labor, like everything else in the market, is worth neither more nor less than supply and demand put upon it. It is sheer madness to battle fact by saying it should be worth more. Imagine an astronomer as insane as this, insisting upon it that the sun ought to revolve around the earth, and therefore refusing to reason upon the fact that the earth revolves around the sun! Merchants have no right to force each other, by mob

violence, to maintain high prices upon their wares. No more have working-men this right when selling their labor. When they find it necessary to employ each other, they are just as exacting as the capitalists in demanding well-done work at low rates.

The capitalist will gladly welcome all unemployed laborers when the prices of his goods can be regulated by the demand for them, instead of, as now, by the high wages he is compelled to pay his men and high prices for his raw materials. He will have no fear of overstocking the markets of a world where men's wants are so numerous and insatiable. But it will not do to let him toy with men's wages at every whim he has. Men must seek for the highest remuneration without combination, compulsion, or restriction. Business-men must seek the highest prices in the same way. Excessive selfishness on the part of employé, as well as employer, lies at the root of the matter. When this is toned down, and each works for the other's interest, things will go better with both. Till then we may expect to see misery, and hear the wail of want from many quarters. Relieve this by giving the laborer something to do, however trifling, and not by alms. Ask the state to do nothing, or you will impose extra burdens upon the worthy, and sink them to pauperage. Teach working-men to live more economically, and practise self-restraint. Advise them to compete with each other in doing the most and best work they possibly can for their employer while in his employ. Teach them that they bring down their own wages, and that this is not their employer's doings. Show them that, if the wages descend slowly and steadily, it will avoid a crash of business, and, making goods correspondingly cheap, do them good rather than harm in the end. Train them into that true spirit of freedom and faith that will enable them to allow fellow-workmen, who are in need, to sell their labor for what they choose. Teach the employers to work for the interests of their men. Teach them to be less avaricious in demanding high profits for themselves. Teach them to give the working-men the highest wages the market will allow. Teach them to be honest and truthful with each other, and the public. Teach each class these points, and the highest substantial advantages to the working-class will soon be realized as a living fact. The present and past troubles are the legitimate fruits of our social immorality. The poor are not the only sufferers. Things, as they now exist, are about the best possible to our present stage of development. With improvement of men's natures will come a corresponding improvement of society. All that we can do is to search after the laws governing such matters, and remove obstructions from the way. With this done, leave all else to the *vis medicatrix naturæ.*

SKETCH OF PROFESSOR SIMON NEWCOMB.

PROF. NEWCOMB was born in the Province of Nova Scotia, March 12, 1835. Both of his parents were of New England descent, their families having emigrated to the Provinces at various times. His father pursued the avocation of village schoolmaster, and from this circumstance the son during his childhood enjoyed educational advantages which were good for the time and place, but exceedingly scanty when measured by any other standard. A taste for arithmetic was developed at a very early age, and before he was twelve years old the embryo astronomer had completed the (restricted) course taught by his father.

From this time he was thrown upon his own resources, reading and studying at random the few books which Providence threw in his way. A traveling peddler sold him Latin and Greek grammars and readers. For a short time he studied the rudiments of French, with a teacher, but acquired a better knowledge of the language from the descendants of the old French settlers, while at the same time an algebra, borrowed from a clergyman, was his constant companion.

At the age of eighteen we find him in the State of Maryland, teaching school—his ancestral calling—but with his active mind constantly engaged in mathematical pursuits. In 1856 Mr. Newcomb was so happy as to make the acquaintance of Prof. Henry, of the Smithsonian Institution, with whom he had corresponded on a scientific subject, and who soon took an active interest in the welfare of his newly-discovered young friend. In conjunction with Mr. Hilgard, Prof. Henry secured for young Newcomb a position as computer for the "American Nautical Almanac," the office of which was then located at Cambridge, Massachusetts.

Here Mr. Newcomb found both the material and the incentive to pursue his mathematical studies of the theories of the celestial motions. He enrolled himself a student of the Lawrence Scientific School, and attended the lectures of Prof. Peirce. After making a study of the works of Laplace and La Grange, he started on the line of original investigation, and has ever since pursued it, with uniform success. In 1861 he was appointed Professor of Mathematics in the Navy, and assigned to duty at the Naval Observatory, Washington, with which he is still connected.

In 1863 he married Miss M. C. Hassler, daughter of the late Surgeon Hassler, United States Navy, and granddaughter of the late Prof. Hassler, the originator and first Superintendent of the United States Coast Survey.

It may seem surprising that, while Prof. Newcomb's name is not

associated with any brilliant discovery or achievement in astronomy, he has, nevertheless, secured as great a reputation as was ever gained by an American astronomer, and is quoted abroad as among the highest authorities in mathematical astronomy. Perhaps the secret lies in the unity of purpose which has characterized all his efforts. His special field has been that of "exact" astronomy—the prediction of the motions of the heavenly bodies from their mutual gravitation—the perfection of the tables and other data, from which the "Nautical Almanac" is prepared, in order that the navigator and surveyor may be enabled to find their positions by sea or land. When the late Admiral Davis founded the "American Nautical Almanac," some twenty-five years ago, the tables and other materials for its construction were extremely imperfect, but Prof. Newcomb's studies have all tended to their improvement.

Prof. Newcomb gained a European reputation while still a computer at Cambridge, by his paper "On the Secular Variations and Mutual Relations of the Orbits of the Asteroids." The question of the correctness of Olher's theory, that these bodies resulted from the explosion of a single planet, had never been decided, because no one had ever investigated the changes which their orbits had undergone in past ages. This was done in the paper we have mentioned, and it was shown that the orbits could never have intersected in a single point, unless they had in the mean while been deranged by some unknown cause.

Since his appointment in the navy his most considerable works, outside of his duties at the observatory, have been the "Investigation of the Orbits of the Two Outer Planets, Uranus and Neptune," accompanied by elaborate tables, which were at once adopted in all the nautical almanacs of Europe and America. In the preparation of these "tables," Prof. J. Henry, his kind and firm friend of now more than twenty years, took great interest, and gladly assisted him by supplying him with funds from the Smithsonian.

In 1867 the observatory published his "Investigations of the Distance of the Sun," leading to the value of the Solar Parallax now most generally adopted, namely, 8".848.

In 1870 he visited Europe to observe the total eclipse in the Mediterranean, and was everywhere received with the highest distinction in scientific circles.

He took an active part in procuring the great telescope for the Washington Observatory, and was in charge of it during the first year or two after its erection, investigating with it the satellites of his two favorite planets, Uranus and Neptune.

When Congress authorized the organization of parties to observe the late transit of Venus, Prof. Newcomb was appointed one of the commission to prepare the plans for those parties, and to arrange for the complete execution of those plans, after the return of those parties

to the observatory. From the first meeting of this commission Prof. Newcomb has acted as secretary thereof. Prof. Newcomb's most recent labors have been on the motion of the moon, and the possible variability of the sidereal day, on which subject he has published several fragmentary discussions. Hansen's tables of the moon have deviated from observation for several years past in a remarkable manner, and he has accounted for the changes by an acceleration in the rotation of the earth on its axis. It is now considered that he has proved the actual existence of this acceleration beyond reasonable doubt.

In February, 1874, he was the recipient of the gold medal of the Royal Astronomical Society of Great Britain. The presentation was preceded by an address by the president, Prof. Cayley, in which, after giving an account of several of Prof. Newcomb's most important contributions to mathematical science, he says: "They exhibit all of them a combination, on the one hand, of *mathematical skill and power*, and, on the other hand, of *good hard work*, devoted to the furtherance of astronomical science." Thus, though belonging to the younger generation of astronomers, Prof. Newcomb has received his full share of honors, both at home and abroad. Graduating as B. S. at Harvard University, in 1858, he is now, *at home*, member of the National Academy of Science, and of the American Academy of Arts and Sciences, in Boston. In 1876 he was elected President of the American Association for the Advancement of Science, and presides at its annual meeting, in Nashville, in August of this year. In 1874 he received the honorary degree of LL. D. from the Columbian University, at Washington, and in 1875 the same honor from Yale. *Abroad*, he was, in 1872, elected associate member of the Royal Astronomical Society of Great Britain; in 1874, corresponding member of the Institut de France; in 1875 he received the honorary degree of Ph. D. from the University of Leyden, at its three-hundredth anniversary. Also in that year he was made a member of the Imperial Academy of Sciences of St. Petersburg, member of the Royal Swedish Academy of Sciences, and member of the Royal Bavarian Academy of Sciences.

CORRESPONDENCE.

To the Editor of the Popular Science Monthly.

SIR: In the last number of THE POPULAR SCIENCE MONTHLY Mr. E. R. Leland replies to my article in the July issue entitled "Over-Consumption, or Over-Production?" misstating some and misconceiving other of my arguments. It would be an infringement on your space for me to follow Mr. Leland through all his assertions, and at best I should be only repeating arguments already made. But Mr. Leland attempts to formulate my theories, and, as I think I can do this more accurately than he, permit me to reaffirm what I have said in this compact form, which will be the briefest and most satisfactory method of meeting Mr. Leland's reply:

1. The resources of Nature are gratuitous; they are practically exhaustless; and, as the activity of capital and the energy of labor are not fixities, large consumption or demand (Mr. Leland talks of *wasteful consumption* as if the word "wasteful" were mine) stimulates the energy of capitalists, leads to the application of improved machinery, brings about better transportation, so that as a result all, or nearly all, products are proportionately increased in abundance because of extended consumption, and the possibilities of consumption. Mr. Leland says: "That the demand for a commodity stimulates the supply is most true, and, where increase is possible, the supply is increased until the widest area of demand is filled at a minimum cost, but it is only by economy that this minimum can be reached." We repeat Mr. Leland's words—"most true." But large consumption is a powerful agent in securing minimum of cost in production; it brings in competition, it leads to the invention of machinery and improved methods of production or manufacture—in fact, minimum of cost is never reached except in those things that are in general use. Consumption or demand leads, therefore, as a rule, not only to greater abundance, but to greater cheapness. But I do not mean, and I did not speak of, *wasteful* destruction, which Mr. Leland dwells upon so much, but of *use*. Waste is foolish, in the first place, because it confers no good upon any one; and, secondly, because it is only the certainty and regularity of legitimate use that exercise a healthful stimulus upon production. Waste, that destroys machinery, permits bridges to go into decay, destroys roads, lets grain rot in its storehouses, burns up cities, exhausts the reserves of capital, is direful; but *use*, which is the means of setting millions of busy hands to work, is another thing. I know the economists say that capital alone determines the fact of production, demand merely governing the direction it shall take; but is it not clear that, if we reduce consumption to its minimum, production will shrivel up?

2. The extravagance of an individual has some essential difference from the extravagance of a whole community. Of course, one bankrupt multiplied ten thousand times simply gives us ten thousand bankrupts. It was scarcely necessary for Mr. Leland to point this out. But a community considered as a unit has for its resources the boundless wealth of Nature, which, as we have already seen, increases with the demands made upon it, so that liberal use makes rather than reduces abundance. This proposition hangs upon the first; if that is true, this is true. By extravagance I simply meant free use, not idle destruction; and what I wished to show is, that Nature yields her treasures in increasing proportion to the activity that demands them, so that we are richer in coal, iron, fabrics, food, etc., because our wants are many, our demand eager, our use of these things abundant. It is perfectly true that if the wealth of a community is simply the aggregate incomes of its members, then the whole must partake of the nature of its parts; but there is a kind of wealth that accrues to the individual and does not to the community as a whole, such as *rent*, for instance, which, enriching some, is a tax upon others, and no addition whatever to the sum total of the wealth of the community; and in like manner there is wealth which accrues to the whole, but is not a part of an individual's income.

3. Mr. Leland makes me affirm that no part of the nation's capital has been lost in unproductive enterprises. There have been, as all know, immense losses in foolish railroad and speculative enterprises; but I consider these losses to have fallen upon our surplus rather than our reserves; that our ability to keep all our machinery in motion, to run our mills, erect warehouses, build ships, construct railroads really needed, do all forms of legitimate productive labor, is not impaired—while, according to Prof. Price, it *is* impaired, and this is the reason of our business distress. I can detect no evidence that business cannot revive be-

cause of insufficient capital, the difficulty being rather that capital is lying idle.

4. I am accused of attributing the business depression to over-production, whereas I distinctly said *speculative* over-production—over-production brought about by centralization of wealth and vast appliances of machinery, which under artificial stimulus produces an excess at one period, and then at another, stopping all production, turns hosts of workmen into the streets idle and empty-handed, followed consequently by a great reduction of consumption.

5. I laid no stress upon coöperation to regulate production, merely mentioning it as the only remedy I could suggest. Such coöperation is doubtless impracticable except to a limited extent. The fear is, there is no remedy, and that we shall have—as, indeed, has been frequently predicted—continually our intermittent periods of overtrading and speculation, offset by those of prostration and suffering. The elimination of speculation and other "crazes"—that is, the maintenance of production in legitimate and healthful relation to consumption—is, as I think, indisputably the only remedy; but how this is to be brought about is more than I can say. Economists, surveying the broad field over long distances of time, are contented to say that these periods are but perturbations; that production in the end does adjust itself to consumption. While this is true, our concern is how to reduce the intensity and duration of these perturbations.

There are other points that call for answer in Mr. Leland's letter; he gives me some elementary instruction as to the meaning of capital and of money; and he decries the fact of "released labor;" but it seems unnecessary for me to take your space merely to vindicate my opinions or to establish my knowledge of elementary principles—your readers can have no concern in these matters. The thing is, to get at the truth of the causes of our business distress, and those interested are referred to the article of Mr. David A. Wells—than whom there is no better authority—in the last *North American Review*, wherein we are told that the community is suffering to-day, "strange as the proposition may at first thought seem, not because we have not, but because we have; not from scarcity, but from abundance;" that is, not from impaired capital, according to Prof. Price; and that "the only remedy is the creation of more wants or demands for our products, and, as a consequence, more and enlarged employments for our labor." That is to say, it is not by the community economically reducing consumption to its minimum that a revival of trade is to come, as we hear asserted on every side, but by the creation of new wants, by the stimulus of consumption. This is the essential basis of my argument.

With respect, yours, etc.,

O. B. Bunce.

"THE TIDES."

To the Editor of the Popular Science Monthly.

The article on "The Tides," in the July number of your Monthly, would be amusing had it not appeared in a scientific periodical of high standing; but, when such erroneous and ill-digested views are set forth in a reputable journal for public instruction, they call for a public notice which they do not at all deserve.

The author of the article referred to has unfortunately adopted the errors of statement and conception generally found in our text-books of natural philosophy, prepared by authors of no authority, for our public and preparatory schools. I have had occasion recently to examine several such books on the subject of "Centrifugal Force," so called, and have found very few that are not in error. If the author of "The Tides" had expended a portion of the time devoted to the elaboration of his subject in an examination of the basis of his explanation—centrifugal force—he could not have reached conclusions at variance with the simplest fundamental principles of physics.

Newton's first law teaches that a body, once set in motion, will continue to move on with uniform velocity in a straight line forever if left to itself. To produce circular motion a constant force directed toward a fixed point must be applied in addition to the original force. The fixed point then becomes the centre of revolution. The original impulsive force (or continued force acting during a finite time), and the constant force directed toward the centre, are the *only* forces concerned in uniform circular motion. "Centrifugal force" expresses merely the resistance of a body to deflection from a straight line in which it tends to move, according to Newton's first law of motion. It is its *inertia* with reference to motion in a specified direction toward the centre. If only that which produces or tends to produce motion or change of motion is force, then there is no such *force* as "centrifugal force;" for the only motions that a body moving in a circle has are tangential, due to the original impulsive force, and the radial *toward* the centre, due to the constant centripetal force. If the centripetal force ceases to act, the body moves on tangentially, in obedience to the tangential force; if its motion of rotation ceases, it falls toward the centre. It can take no other direction of motion unless some force, additional to those required for uniform cir-

cular motion, is impressed upon it. "Centrifugal force" is a misnomer—a convenient fiction to represent resistance. Resistance or inertia only *opposes* motion; it never *produces* it; and is, therefore, not *force.* Hence any explanation of phenomena that assigns "centrifugal force" as the *real* cause in producing motion or change of motion is wholly erroneous, and subversive of Newton's first law. No such resort to "centrifugal force" is necessary in the explanation of the tides.

I must confess entire ignorance of the experimental demonstration that bodies weigh more or are heavier at midnight than at any other hour of the twenty-four. If that *be true*, and the cause assigned by Prof. Schneider a sufficient explanation, then the lunar midnight should produce the same effect as the solar. On this point allow me to quote from Sir William Thomson and Prof. P. G. Tait's "Treatise on Natural Philosophy," vol. i., page 662. The authority of these physicists must be acknowledged: "Hence as the moon or anti-moon (an imaginary moon 180° from the real one) rises from the horizon to the zenith of any place on the earth's surface, the intensity of apparent gravity is *diminished* by about $\frac{1}{8000000}$ part; and the plummet is deflected toward the point of the horizon under either moon or anti-moon by an amount which reaches its maximum value when the altitude is 45°. The corresponding effects of solar influence are of nearly half these amounts."

Does Prof. Schneider mean to subvert Newton's third law that action and reaction are always equal? If he can prove that the centripetal force for any point of a revolving body is greater or less than its reaction, the "centrifugal force," he will certainly *disprove* Newton's law, and compel a reconstruction of most, if not all, mechanical propositions.

His statements respecting the value of "centrifugal force" (properly centripetal force or acceleration toward the centre) as depending on the radius of curvature are incorrect. It is not unconditionally true that "in a short curve the centrifugal force is very great." On the contrary, if the *time* of revolution is *constant*, the "centrifugal force" varies directly as the radius, increasing as the radius increases. If the *velocity* of rotation is constant, "centrifugal force" varies inversely as the radius, increasing as the radius decreases. Neither of these conditions is met in the comparison of the revolutions of the earth and the moon in their orbits, since neither times nor velocities are the same in the two orbits. In fact, the acceleration of the earth (and, therefore, of the moon) toward the sun is about $\frac{23}{100}$ of an inch; while that of the moon toward the earth is a little less than $\frac{11}{100}$ of an inch a second. The acceleration of the earth toward the common centre of gravity of earth and moon is only a small fraction of the moon's acceleration toward the same point. These accelerations are the measures of "centrifugal force." Hence, according to Prof. Schneider's theory, the solar tide should be many times greater than the lunar.

My amazement reaches a climax when I read, near the close of the article in question, that "centrifugal force acts in a line tangent to the earth's orbit;" or, "in a direction at right angles with the radius-vector." Really, Mr. Editor, your compassion should have saved Prof. Schneider from making such an egregious blunder.

In reference to the true explanation of the tides, the length of this communication will allow me to add only that, if Prof. Loomis, in his admirable "Treatise on Astronomy," had applied to the tides the same explanation and figure, *mutatis mutandis*, that he uses in estimating the amount of the sun's disturbing effect on the moon's motion, no uncertainty would remain in the mind of teacher or student respecting the cause of the tides.

H. S. CARHART.

NORTHWESTERN UNIVERSITY,
EVANSTON, ILLINOIS, *July* 2, 1877.

"THE ZODIACAL LIGHT."

To the Editor of the Popular Science Monthly.

PROF. BRAME'S article on "The Zodiacal Light," in THE POPULAR SCIENCE MONTHLY for July, may make a recent observation of that phenomenon of interest. About eight o'clock in the evening of July 3d my attention was called to a peculiar appearance of the sky. The sun had been below the horizon about an hour. From the point in the horizon where it was last seen a broad band of pink or rose-colored light followed the ecliptic across the sky to the opposite horizon. Its south limit was sharply defined—its intensity nearly the same from horizon to horizon. Its north limit was not determinable, the pinkish light extending nearly or quite to the horizon, filling the entire northern sky. The southern sky from the ecliptic was of the normal blue color, with the exception of a single streak of a darker blue, extending from the point where the sun sank below the horizon about 90° into the southern sky, making an angle of say 30° with the southern limit of the rose-colored light, or the ecliptic.

There were none of the auroral characteristics. The light was steady, and the entire exhibition as described lasted for twenty minutes, when it all faded away gradually, leaving a perfectly clear sky, with only a trace of the pink in the west.

CHARLES A. MOREY.

WINONA, MINNESOTA, *July* 5, 1877.

To the Editor of the Popular Science Monthly.

Reading an item, attributed to a writer in *Science Gossip*, on the "Food of the Water-Tortoise," in the "Popular Miscellany" of your July number, showing that that reptile appears "to have a special relish for the food of the cat," it occurred to me that I might also relate a fact which came under my own observation bearing upon this subject: During last summer I found an ordinary snapping-turtle (*Chelydra serpentina*) in a field adjoining my residence, and near a brook which empties into Boone River, a few rods below. It was a vicious old fellow, and more than ordinarily curious to me from the fact that it had more than a hundred leeches clinging to its shell and various portions of its skin. I had some suspicions that my captive had committed depredations upon my young black Cayuga ducks; but disliking to murder it "in cold blood," I let it go, and it speedily disappeared in a deep hole in the brook. Some days afterward, while passing near the place, I heard a duck squawling and splashing in the water, and went at once to learn the cause. I found that this same turtle had seized one of my ducks by the foot, and was trying to drag her under the water —for "carnivorous purposes!" The duck was full-grown, and would have weighed five or six pounds, but would soon have been killed if I had not rescued it. I got hold of the bird and drew her to the shore, but the turtle held on, till I was able to secure him. Of course, he caught no more of my ducks.

But this reminds me of another interesting fact. These black Cayuga ducks—said to have descended from ancestors captured at Cayuga Lake, New York, by reason of long domestication and high feeding—have come to have very heavy bodies and short, small wings. Owing to the disuse of the latter, they have become so far atrophied that "well-bred" birds are quite incapable of flight. In the summer of 1875, one of my half-grown ducklings had the misfortune to lose one of its legs. After some days' absence it hobbled home from the river on one foot, the other having no doubt been torn off by one of these same predacious turtles. The little bird speedily recovered from the injury, though it never attained the full size of its mates. It hopped about quite briskly on its single foot, using its wings to surmount obstacles or increase its speed. The consequence was that its wings grew to such size and length that it was capable of flying twenty or thirty rods, and possibly much farther. It could rise easily out of the water, and once on the wing was able to clear the bank and a high fence—in all, a quite abrupt rise of fifteen or twenty feet —and thus speedily reach home, while its mates were slowly waddling through the grass. My flock of ducks showed in a striking manner the result produced by the long disuse of their wings; while the unfortunate one-legged bird as strikingly evidenced how rapidly "compulsion to more diligent use" produced a very decided and important modification of the wings, increasing their strength, as well as the length of the feathers.

Charles Aldrich.

Webster City, Iowa, *July* 6, 1877.

EDITOR'S TABLE.

SPECTROSCOPIC DISCOVERY OF OXYGEN IN THE SUN.

Celestial chemistry has taken another stride forward. In a paper recently read before the American Philosophical Society, and printed in the *American Journal of Science and Arts*, Dr. Henry Draper announces the discovery of oxygen gas in the sun, the fact being arrived at and verified by a long course of spectroscopic observations.

Viewed in any of its numerous aspects, this discovery is of immense interest. Whether as an extension of our knowledge of solar physics, solar chemistry, and the nature of the spectrum itself, or as throwing further light upon the constitution of the universe; whether as bearing upon cosmical theories that have attracted much attention, or as a triumph over the difficulties of complicated experiment, or, finally, as an illustration of hereditary genius in science, where a line of research opened brilliantly by the father nearly half a century ago, has been pursued with equal brilliancy to this crowning result —however regarded, this exploit of the younger Draper must command unqualified admiration.

As has been repeatedly shown in our

pages,[1] the elder Draper was one of the early and most successful explorers of the chemical relations of the luminous spectrum. He was a pioneer in this line of investigation, and the first to make extensive use of photography in this branch of research; and he was so far in advance of his time, that his discoveries were totally unappreciated. But he furnished the fortunate men who followed him with their tools to reap the splendid harvest of spectroscopic discovery, which has so impressed the world during the last eighteen years. We have never had any doubt that history would set all these things right, but the venerable doctor will at any rate be easy in the assurance that the sceptre has not departed from his family.

When it was established that the light emitted by vaporized and incandescent bodies gives spectra by which they may be identified, the passage was rapid to the discovery of chemical substances by the analysis of light. A study of the spectra of the sun and stars soon gave evidence that they contained forms of matter with which we are familiar upon earth. All the metals, for example, in a state of luminous vapor, yielded bright lines in the spectrum so distinctive in each case that there was no possibility of mistaking them. When these were carefully mapped and compared with the spectra from the sun and stars, such a startling mass of coincidences was at once disclosed, that there was no escape from the conclusion of a common causality, or that these metals exist also in the stellar bodies. There was but one serious difficulty. The lines obtained by the combustion of the metals were bright and colored, while the corresponding lines in the solar and stellar spectra were all dark. Kirchhoff resolved the difficulty in 1859, by showing how the bright lines may become dark lines by absorption in such conditions as the celestial bodies furnish; and it was thus not only established as a fact that there are various terrestrial metals in the sun and stars, but their mode of manifestation was brought into complete harmony with theoretical requirements.

[1] *See* Popular Science Monthly, vol. iv., p. 361; vol. ix., p. 290.

The nebular hypothesis, which had been growing for a century, and which assumed the origin of all the bodies in the solar system from a common nebulous source, was, of course, at once and profoundly affected by the new revelations. It was proved that there are common elements extensively distributed among celestial bodies, which confirms the hypothesis that they have a common origin. Not only was there new and positive proof of the existence of nebulous matter in the celestial spaces, but the ultimate elements of which material Nature is constituted were shown to be universal, and the nebular hypothesis was thus strongly confirmed. Yet a difficulty at once arose, that the main predominant elements of terrestrial Nature were not found to exist in the sun and stars. The evidence, of course, was negative, but it was held by many to be weighty, in disproof of the nebular doctrine. If the non-metallic elements, it was said, which form the principal part of terrestrial objects, do not exist in the sun, the derivation of that body and of its encircling planets from the same primeval source is impossible. Dr. Draper has now proved that oxygen in large proportions exists in the sun (and probably nitrogen also); and his discovery can therefore only be regarded as lending further and more powerful confirmation to the nebular hypothesis.

Dr. Draper's paper, in the *American Journal of Science and Arts*, is accompanied by an illustrative diagram, which brings the demonstration before the eye of every reader. It exhibits the spectrum of the sun, and that which is produced from air, so juxtaposed that the fact and the extent of the identity of the lines in the two representations are

seen at a glance. The matching and identification are even more complete than they were in the original experiments of Kirchhoff with the metals, for here it is not necessary to invoke a theory for the unification of bright and dark lines; the bright lines of the spectrum of oxygen being continuous with the bright lines of the solar spectrum. It is, indeed, because the solar oxygen reveals itself by bright lines that these have not been earlier detected, as they have been masked and concealed among the unoccupied luminous spaces, between the dark lines that have hitherto been the main objects of attention.

Dr. Draper has been occupied for several years with this investigation—in fact, he has grown into it. Besides his inherited aptitude, and life-long training in this delicate line of manipulation, and his thorough familiarity with the peculiar difficulties of these investigations, his work could only have become successful by means of a combination of appliances, some of which are only lately available. His task was to produce a gas spectrum, and maintain it at a brilliancy which would admit of its being photographed alongside of that of the sun itself. Oxygen is made incandescent by electricity. The most ample, steady, and sustained command of this agent was therefore indispensable. This was secured by the Gramme machine, a dynamo-electric engine connected with a large induction-coil and a battery of Leyden-jars. The impulse was furnished by a Brayton's petroleum-motor, which "can be started with a match, comes to its regular speed in less than a minute, and preserves its rate entirely unchanged for hours together." This was belted to the Gramme machine, which, at its usual rate of running, gave 1,000 ten-inch sparks per minute. This "torrent of intense electric fire," consisting of twenty ten-inch sparks per second, was passed through Plücker's tubes, containing oxygen, the spectrum of which is thrown upon a sensitive photographic surface, while the solar spectrum is formed beside it, and both are fixed together upon the tablet. The embarrassments of the investigation are thus referred to in Dr. Draper's paper:

"This research has proved to be more tedious and difficult than would be supposed, because so many conditions must conspire to produce a good photograph. There must be a uniform, prime-moving engine of two-horse power, a dynamo-electric machine thoroughly adjusted, a large Ruhmkorff coil with its Foucault break in the best order, a battery of Leyden-jars carefully proportioned to the Plücker's tube in use, a heliostat which of course involves clear sunshine, an optical train of slit, prisms, lenses, and camera well focused, and, in addition to all this, a photographic laboratory in such complete condition that wet, sensitive plates can be prepared which will bear an exposure of fifteen minutes and a prolonged development. It has been difficult to keep the Plücker's tubes in order; often before the first exposure of a tube was over, the tube was ruined by the strong Leyden sparks. Moreover, to procure tubes of known contents is troublesome. For example, my hydrogen-tubes gave a spectrum photograph of fifteen lines, of which only three belonged to hydrogen. In order to be sure that none of these were new hydrogen-lines, it was necessary to try tubes of various makers, to prepare pure hydrogen and employ that, to examine the spectrum of water, and finally to resort to comparison with the sun."

In regard to the significance of the inquiry in relation to spectroscopic study, Dr. Draper remarks:

"We must, therefore, change our theory of the solar spectrum, and no longer regard it merely as a continuous spectrum with certain rays absorbed by a layer of ignited metallic vapors, but as having also bright lines and bands superposed on the background of continuous spectrum. Such a conception not only opens the way to the discovery of others of the non-metals, sulphur, phosphorus, selenium, chlorine, bromine, iodine, fluorine, carbon, etc., but also may account for some of the so-called dark lines, by regarding them as intervals between bright lines."

SEELYE ON CIVILIZATION AND RELIGION.

The inaugural address of Prof. J. H. Seelye, upon assuming the presidency of Amherst College, has attracted the marked attention that was to have been expected from the eminent scholarship and versatile accomplishments of the author. The interest, moreover, has been especially heightened by the intrepidity evinced in his choice of a subject. President Seelye did not shrink from the responsibilities of the occasion. Taking the helm of a leading orthodox institution for the education of young men, founded we are told "as a breakwater to Harvard, which had been captured by Unitarianism," and, therefore, as a bulwark of evangelical faith, he addressed himself to one of the great vital issues which have been forced upon modern theology and made prominent by the later advances of scientific thought. His subject is the relations of religion to civilization and to education.

President Seelye's argument has been interpreted as an assault upon the doctrine of evolution, and by his admirers as an annihilation of it. The *Christian Intelligencer*, for example, says, "It has fallen like a bomb into the camps of skepticism;" and has a startling significance "in this day of theological enervation and cowardice before a dogmatic evolutionism." Again, the writer says: "He first of all joins issue with the superficial and unsupported notion that there is 'an inherent law of progress in human nature by which it is constantly seeking and gaining for itself an improved condition,' and contends, on the contrary, that there is a 'law of deterioration.' Most acutely and eloquently does he prick this bubble, blown of sentimentalism and conceit, which has so long been suffered to pass unchallenged, and even been hastily adopted by Christian thinkers."

Now, with this estimate of the address we can hardly agree. If evolutionism be a bubble, we doubt if it has been reserved for President Seelye to prick it; and if the address be a bombshell, there are grounds for thinking that it is the president's own party that must beware of the explosion. His positions are: 1. That the historic phenomena of national decay disprove the doctrine of evolution; 2. That whatever progress there has been is due to the supernatural. He says:

> "No historical fact is clearer than that human progress has never revealed any inherent power of self-perpetuation. Arts, languages, literature, sciences, civilizations, religions, have in unnumbered instances deteriorated and left a people to grope in the shadow of death whose progenitors seem to rejoice in the light of life."

Again:

> "It was not the construction of his house that taught man to build his temple, but exactly the other way. The same is true with sculpture, painting, poetry, and music. It was a religious impulse which gave to all these their first inspiration. The oldest monuments we possess of any of these arts are associated with some religious rite or faith. But, more than this, we must also notice the undoubted fact that the arts have grown in glory just as the religious sentiment has grown in power."

In brief—

> "The supernatural is the Alpha as well as the Omega of human thought."

These are favorite ideas with President Seelye, which he has expounded elsewhere, and we shall perhaps get his view more sharply before us by quoting briefly from an earlier statement, also made with deliberate care. In the article on "Darwinism," in "Johnson's New Universal Cyclopædia," he says:

> "The history of men is full of instances of deterioration. If we weigh it simply by number, whether of years, or of nations, or of individuals, degeneration and decay vastly preponderate. Where is the civilization now of Tyre, and Carthage, and Babylon, and Nineveh? and where are the arts which built the Great Pyramid and Baalbec? All over the world we have evidence of a tendency among nations and men to sink away from civilization into barbarism, but history

does not show an instance of a nation rising by its own efforts from barbarism to civilization. . . . The incontestable fact is, that human nature reveals no inherent impulse to improve or perfect itself. History gives unnumbered cases of a downward tendency, but not a single instance of a self-evolved progress. The lamp which lights one nation in its advancement has been always lighted by a lamp behind it. Civilization is never indigenous; it is an exotic plant wherever found. This is the simple truth of history, which makes all such discussions as Mr. Darwin's respecting the descent of man as false to fact as they are abhorrent to philosophy."

President Seelye's inference that because nations decay there is no evolution of humanity, does not appear to be conclusive. The considerations alleged as making the doctrine of Darwin's discussions "false to fact" seem to us to be in harmony with it, and the natural consequence of it. President Seelye appeals to the historic phenomena of deterioration, disintegration, and decay among nations and civilizations as disproving the principle of development; but how is decay made possible except by previous growth, and how can a community degenerate unless it has first been organized and unfolded? The conclusion is certainly logical that before civilizations can dissolve they must first be evolved, so that to affirm a "law of deterioration" is necessarily to imply a previous "law of evolution." In the normal course of Nature the effete and outworn must pass away. The spent molecules of our tissues have to be eliminated, that more vitalized particles may replace them. Individuals when they get old and useless die out of the community, that their younger and more vigorous successors may carry on the work. On the larger scale, but in the same way, nations die out as civilization progresses; while civilizations themselves are spent in the larger advancement of humanity. We may brood with morbid sentiment over excretion, decay, and death, until there seems to be nothing else; yet these are normal things, and are simply the correlates and the consequences of growth and life. President Seelye declares that in the past career of humanity "degeneration and decay vastly preponderate;" he should have explained how that can be—how there could be a fall without a previous rise to make it possible. If he means that much the greater number of nations and civilizations come apparently to naught, we have simply to say that this is the law in the realm of life: the eggs that are wasted and the seeds that are scattered and lost vastly preponderate over those that mature. Nature is profuse in the waste of life, and sacrifices multitudes where but few are perfected. But is not this ruthless and wide-spread destruction only a part of Nature's policy for the attainment of grand results? The evolutionists affirm continuity of influence in the sphere of life, and that some of the nations and civilizations which decline and die pass on the impulses which they have gained to reappear in succeeding and higher stages of national and racial development. President Seelye recognizes this principle of continuity in saying, "The lamp which lights one nation in its advancement has been always lighted by a lamp behind it." National advancement is here conceded, and also a series of advancements, each depending upon a preceding one. But is there nothing gained by accumulated experience? Is there no general progress resulting from the advancement of nations in succession and under different circumstances? If the dissolution of states and the decay of civilizations do not break the continuity of those agencies by which man is civilized, how can they hinder that gradual improvement of the process and heightening of the effects which evolution implies as the consequence of prolonged, varied, and accumulated national experiences?

If we try President Seelye's logic in a more special case, its quality will, perhaps, be more apparent. "Behold,"

he might say, "the orchards of the world! They deteriorate and decay, and nothing remains of them at last but withered branches, dead trunks, and rotten stumps. Where are the orchards mentioned by Pliny, the orchards of the middle ages, the old Indian orchards, or even the orchards of the Revolution? The history of apples does not show an instance of an orchard growing by its own efforts. The vitality which impels one orchard in its growth has always been kindled from the vitality of an orchard behind it. This is the simple truth of history, which makes all such discussions as Mr. Darwin's respecting the descent of the golden pippin from the sour and miserable crab as false to fact as they are abhorrent to pomology."

In regard to the second and main position of President Seelye's address respecting the relations of religion to civilization, it is chiefly interesting from the indications it affords of the rationalistic tendencies of New England orthodoxy. We by no means object to the prominent part which he assigns to religion in promoting the progress of man; and are only agreeably surprised at the catholicity of his position. The president says that "human nature reveals no internal impulse to improve and perfect itself;" this he maintains is due to an external impulse, to a power above man, which he assumes to be the agency of supernatural religion. But the transition from barbarism to civilization has taken place on an extensive scale. President Seelye asks, "Where are now the civilizations of Tyre and Carthage, of Nineveh and Babylon?" His question implies that they once existed, and his hypothesis of their origin is that they were the product of religious inspiration and supernatural agency. It will be hardly claimed that those ancient and extinct civilizations were due to the Christian religion; but if not, then they were caused by other religions potent with genuine inspirations and supernatural in their elevating influence. Yet is it not the essence of orthodoxy that it is the only true faith, and that all other so-called religions are delusions, impostures, and heathenish superstitions? The implication of the inaugural address contravenes evangelical theology by assuming that there are other religions than that professed in New England, which are genuinely attested as of supernatural influence by their civilizing impulses, and which have been in operation whenever and wherever there has been any improvement in the condition of humanity. Now, this recognition of the universality of genuine religious influences, as opposed to the exclusive claims of any particular system, we understand to be the broad ground of rationalism; and, if Amherst orthodoxy can accept it, we shall certainly be the last to complain. We only hope, however, that this surrender, horse, foot, and dragoons, to ultra-rationalism, is not to be considered as a bomb-shell in the camp of evolution.

It is a serious question whether President Seelye has not here put a strain upon the claims of supernaturalism which endangers them. Granting the universality of the religious agency, he must explain why it is not always efficient in the work of elevation. The president points impressively to the phenomena of national degeneracy and decay. Viewed as a part of the order of Nature, these phenomena are explicable; but, from President Seelye's point of view, what reason is there why all that had been gained should be thus thrown away? His theory that true religious influences are coextensive with all phases of human progress is an important step in the liberal direction; and his further assumption that the rhythmic successions of progress are due to an intermittent supernaturalism can have little other tendency than to eliminate the supernatural from the investigation of the subject. Why should President Seelye

stop half-way, and, having taken latitudinarian ground in regard to the extent of true religious influences, why should he not complete the work of rationalization by recognizing the religious element as a necessary and indestructible part of the constitution of human nature?

The question of the agencies by which man has been civilized or failed to become so, and which determine his present advancement or retrogression, involves forces which do not belong to an imaginary sphere of mystical caprice, but to the orderly course of natural things which it is the proper office of Science to explore. The religious agency must submit to this ordeal, and be dispassionately studied in its laws of action in connection with and in the same way as all the other agencies which enter into the great result, and which are just as divinely ordained as that to which theologians are wont to ascribe everything, and of which they claim to be the special guardians. President Seelye reëchoes the old assumption, although in a manner which shows how far his law of decay has already taken effect upon orthodoxy under the liberalizing influence of Science. But if the reader desires to obtain a better idea of the progress that the scientific method has really made in its application to the study of civilization, and to contrast its results with those of preceding methods, let him carefully read the opening article of the magazine in his hand.

LITERARY NOTICES.

Nomisma; or, Legal Tender. By Henri Cernuschi. New York: D. Appleton & Co. Price, $1.25.

This book contains the testimony given by M. Cernuschi, the well-known French bimetallist, before the United States Monetary Commission in February last, together with several of his essays reprinted from other sources. Although the work of an ardent advocate of a double standard, defending his views with ability, the book is not one which would afford much comfort to the silver party of this country. We commend it to them for perusal; they will find well stated the extent of the mischief which would come from the adoption of the double standard by the United States, unless a similar step be taken by all commercial nations. From it also the greenback-men might learn that a prime essential of good money is that its issue be an automatic issue which no one can control—something independent of human agency—and this, of course, is an attribute that paper-money can never possess. As to the merits of a bi-metallic system, if it could be made universal—if the same ratio between gold and silver, and the same mint laws, could be established the world over—it is a question upon which a great deal is to be said on both sides, and certainly M. Cernuschi puts his side of the case very strongly. But we cannot help thinking that, practically, it is of about as much importance to us as a question of lunar politics. The prospect of England, for example, abandoning the single gold standard is too remote for this phase of the question to be taken into present account. It is an interesting economic speculation, and nothing more.

It may be added that M. Cernuschi proposes to make silver just as good as gold for all purposes of money; worth just as much. He has, therefore, little in common with our silver-men: they would cease to care about the "dollar of our fathers" if it were made as good as gold; they want it only because it is worth less, and can be made the means of forcing a composition upon their creditors at something less than one hundred cents.

Scientific Basis of Delusions. By G. M. Beard, M. D. Pp. 47. New York: Putnam's Sons. Price, 50 cents.

The author, in the introduction to this little work, tells us that it is preliminary to a "work on the Philosophy of Delusions, which will aim to unfold in detail the phenomena of the Involuntary Life, including Trance, and to give practical suggestions for the reconstruction of the principles of evidence in their application to history and

to logic—to science and to law." In the present volume he proposes a new theory of trance, and considers its bearings on human testimony. Trance—whether natural as somnambulism, or self-produced as by so-called "trance-speakers"—results from activity of a portion of the brain-substance while the remainder sleeps: this is the "Involuntary Life." In this state men see visions, receive revelations, and have ecstasies, after the manner of Mohammed, the mediæval saints, and Swedenborg.

Oriental Religions and their Relations to Universal Religion.—China. By Samuel Johnson. Boston: Osgood & Co. Pp. 975. Price, $5.

The author of this work is an Oriental scholar of fine accomplishments, and a philosophical student of theology in a very broad and liberal sense. He is a transcendentalist, and like Emerson and Ripley he formerly preached, but like those worthies he outgrew the function of pulpit teacher, but only to devote himself more assiduously to the pen. Starting with the religious problem of humanity, and treating it with the freedom and boldness of the transcendentalist, Mr. Johnson was soon carried beyond the narrow boundaries of the faith he had inherited, and was powerfully drawn to the consideration of those ancient religions of the East which are celebrated alike for their antiquity, the vast multitudes of their believers, and the philosophical interest of their doctrines and dogmas. This line of inquiry had such fascination for Mr. Johnson, and seemed so full of promise as a source of enlargement and a more catholic spirit to Christian thinkers, that he resolved, twenty years ago, to devote himself to the exposition of the Oriental faiths in connection with the life of the Eastern peoples, for the advantage of English readers.

In 1872 he published the first volume of this research on the "Faiths, Religions, Philosophy, and Life of India," as a contribution to the natural history of religion. His point of view was rational and scientific, and he delineated the characteristics of the Hindoo mind, its traditions and social forms, its piety and morality, and the speculative principles, ethics, and humanities of Buddhism, with a deep sympathy for the human elements involved, but with the same disciplined coolness of temper with which Herschel explored the heavens, and Lyell investigated the crust of the earth. "I have written," he says, "not as the advocate of Christianity or any other distinctive religion, but as attracted on the one hand by the identity of the religious sentiment under all its great historic forms, and on the other by the movement indicated in their diversities and contrasts toward a higher plane of unity on which their exclusive claims shall disappear."

The second volume in the same line of study now appears, and is devoted to China. This is especially opportune, now that we have the Chinese problem upon us in so imminent a form on the Pacific coast. The Californians will deal with it in the light of race-prejudice, and in its passionate and sordid aspects; but the intelligent mind of the country will desire to inform itself regarding the real character of this extraordinary people. To all who are thus inclined Mr. Johnson's volume will be full of grave instruction. It is not a mere superficial delineation of Chinese life, such as a traveler would give us who had been impressed by its sensuous aspects, but it is an analysis of the Chinese mind, an ethnic study, and the survey of a civilization. Education, government, language, literature, history, and poetry, are taken up systematically in the division of "structures," and an immense amount of most important information is here compactly presented. It is of but little use to talk to Americans about education anywhere else in the world; yet, as we are rapidly sliding into the Chinese system of education by state control, our people might profitably look into the working of that system where it has had prolonged trial and worked out its legitimate consequences.

Mr. Johnson has not failed to point an incidental moral in this direction. He says: "Chu-tsze defines learning as imitation—conformity to a prescribed standard; and in these schools even organization holds an inferior place to the mere act of 'repeating after the teacher, each by himself, in a shrill voice, rocking to and fro.' This perfect image of automatism is not without resemblance to the arrangements into graded

classes, so much admired in our Western school systems, and to those arts of 'reading in concert' which are believed to have such virtue in our democratic culture.

"It would in fact be difficult to imagine a better outward symbol of the mental status produced by these processes of an excessive organization, so widely admired in the public schools of America. They tend to destroy all possibility of original force. Reading, for instance, is becoming reduced to as purely mechanical a conformity to prescribed tone, time, and emphasis, as the Chinese custom of repeating words after the teacher has produced without any organization whatever. Chinese boys, rocking out their parrot tones, eagerly copying the master, or 'backing the books,' do but openly confess, in their noisy routine of imitation, the mental slavery which our prevailing system disguises under the varnish of a 'drill.' 'Reading in concert' has played its part in the Chinese system also, with effects upon voice and manner which we need not cross the hemisphere to find in full operation.

"Concerning 'imitation' as a principle of culture, let us add that, false as it is, its moral quality at least is higher when it follows, as in China, a type that does not change with human caprice, than when it is subject to arbitrary crudities and idiosyncrasies imposed on the pupils by individual teachers. In both cases, however, the real ultimate reference is to an all-powerful authority in that public sentiment and common belief of which these educational systems are meant to be the expression. And when this *public control* has become all-pervading, as it steadily tends to be, whether as Chinese tradition of ages, or American fashion of the hour, its effect through *imitation*, in leveling and trimming young minds into a dull, self-satisfied uniformity, is indisputable. In the course of ages it has cast all Chinamen in one mould, and made their intellectual productions as monotonous as their physical type. The warning is for us, even at the opposite pole of social and political character."

Of moral education the author says: "More prominent than rote-work in the programme of the school system is respect for moral laws as eternal and divine. Modesty and humility; reverence for the old; the evil of war and the wickedness of cruelty and conquest; the love of truth, purity, and self-restraint; delicacy of feeling, devotion to duties, fidelity to functions—are the burden of this popular teaching, the very substance of text and precept. I believe, not only that the whole series of reading-books used in the schools of China does not contain a single impure precept, but that there is scarcely one noble conception of duty and humanity that cannot be found represented in the daily recitations of these children of a grand ethical literature, who are taught to prize it, not with slavish superstition, but for the naturalness of its ideal. Nor does this textual teaching fail of a practical basis in the home. It would be difficult to find any treatise on home education more admirable than the 'Instructions of the Sacred Edict,' whose utilitarian wisdom is here overflowed by tenderest sentiment."

In regard to Chinese education in manners, Mr. Johnson remarks: "As the moral relations are expressed in a concrete ideal, in which no change is supposed possible, so they are embodied in rites and ceremonies which share their sacredness. As the child learns ideas in the form of actual written characters, so he conceives duties in the form of strictly-regulated actions. Hence the prime importance of the 'proprieties' in education. They are not affectations, but recognized as the natural order of conduct, the virtue of behavior. . . . The authority of fixed rules of behavior, while scarcely more absolute than that of fashion in Western society, is not, like fashion, detached from the highest law of ethics and faith, but is strictly identical with it. To the Chinese, their ceremonial is simply man in his manifold relations. Its minute rules, which appear to exhaust the possibilities of prescription, are believed to express man's normal relations to the universe. They seem, in fact, to have historically grown out of the national consciousness of these relations, instead of being imposed by arbitrary authority or transient will. What they correspond with in Western life is not our etiquette, red tape, or religious formalism, but such conformities as are admitted by all of us to be natural, proper to all right

performance of functions, and therefore of highest import. These conformities would of course differ from those of the Chinese, being based on more complex relations and wider knowledge of Nature, and hence more open to changes of detail; but their ethical ground is really the same. Thus the minute ritual of Chinese filial piety consists in routines of conduct which are recognized as beyond all question the best, and indeed the only, ways in which an ideal love and reverence can be fulfilled. It is sufficiently clear, from the spirit of these prescriptions, that this minuteness itself is simply an endeavor to inspire the whole of domestic life with real reverence and love."

After a broad sketch of the Chinese character and quality, Mr. Johnson passes to a study of the Chinese sages, their doctrines and influence, and the national beliefs on religious subjects, the development of Chinese Buddhism, missionary experiences, and closes his work by a presentation of the philosophy, metaphysics, and anthropology, that prevail in China. We cannot here even attempt to give the author's conclusions upon many important topics which he considers, and will only say that while he evidently has great respect for much that is to be found in the institutions and ideas of this great division of the Oriental world, he is by no means an undiscriminating admirer of everything Chinese. Of course they are benighted heathen, and we send missionaries to instruct them in better religious ways. This attitude, however, is not altogether favorable to a just judgment of the Chinese character, and Mr. Johnson has done an excellent service in correcting our prejudices and giving us truer views of the faith and life of so large a portion of the human family.

A Hand-book of Descriptive Astronomy. By George F. Chambers, F. R. A. S., of the Inner Temple, Barrister-at-Law. New York: Macmillan & Co. Pp. 938. Price, $10.

This is in all respects a most excellent book on astronomy, clear, full, splendidly illustrated, carefully accurate, and in a high degree popular. The first edition was issued ten years ago, and a third being now called for, the author has thoroughly revised it and added two hundred pages of new matter, bringing it sharply up to the time. His reason for making the book is thus stated: "There is a lack of works in the English language which are at one and the same time attractive to the general reader, serviceable to the student, and handy, for purposes of reference, to the professional astronomer; in fact, of works which are popular without being vapid, and scientific without being unduly technical." In regard to the present edition Mr. Chambers says: "There is scarcely a single page which has not been to a greater or less extent dressed up, or in some way amended, with the object of making its statements more accurate in substance or intelligible in diction. The most important changes will be found in the chapters dealing with the sun, sidereal astronomy, and astronomical instruments. The descriptions of clusters and nebulæ have been made more numerous, and the lists of objects critically revised one by one actually at the telescope, so as to make that portion of the work more completely than formerly a *vade mecum* for the mere star-gazer, who is an astronomer simply in the respect that he is the owner of a telescope. Indeed, it has been chiefly with this idea in view that so much additional matter has been introduced into the chapters relating to astronomical instruments. The 'Practical Hints' and suggestions have been gathered from so many sources, and embody the collective wisdom and experience of so many men, that they cannot fail to deserve attention. I believe also that this volume now stands alone in its full description, so far as regards the wants of amateur observers, of the mounting and use of reflecting telescopes."

List of Elevations, principally in that Portion of the United States west of the Mississippi. By H. Gannett, M. E. Washington: Government Printing-Office. Pp. 164.

This fourth edition of the work named above embodies the results of its author's continued labors down to 1877. It contains profiles of nearly all the railroads in the region west of the Mississippi; elevations of many thousands of points; mean heights of the States and Territories; slopes of the principal streams in the West, etc. A map of the United States, in approximate

contours of 1,000 feet of vertical intervals, and embodying all the results of the author's researches on elevations, accompanies the work. We are informed that, "to express still more clearly the facts brought out by the map, it is the intention of the Survey (Hayden's) to make shortly a relief model of the United States on the basis of this map."

Influence of Physical Conditions in the Genesis of Species. By J. A. Allen. (From the *Radical Review.*) Pp. 33.

Mr. Allen, in enforcing his thesis that the "conditions of environment" are the principal factors in modifying species, adduces some very instructive examples of the progressive enlargement of certain peripheral parts of animals as we go from the north to the south. Thus the ears of wolves, foxes, some deer, and hares, are larger in southern than in northern individuals of the same species. In birds, the enlargement of the bill, claws, and tail, is specially noticeable—the bill being peculiarly susceptible of variation. This, the author remarks, accords with the general fact that "all the ornithic types in which the bill is remarkably enlarged occur in the intertropical regions." A similar progressive change southward is remarked in the color of animals, especially birds.

The Geology of the Eastern Portion of the Uintah Mountains. By J. W. Powell. Washington: Government Printing-Office. Pp. 217.

The region described in this report by Prof. Powell comprises three great geological provinces, designated respectively the Park Province, the Plateau Province, and the Basin Province, succeeding one another in this order from east to west, and all lying east of the Sierra Nevada and west of the great Plains. The whole region is one of considerable geological interest, as presenting on a large scale three great categories of facts, namely, those relating to displacement, degradation, and sedimentation. The formations here studied have an aggregate thickness of 50,000 feet, and embrace strata of the Palæozoic, the Mesozoic, and the Cenozoic ages. The volume is fully illustrated with plates and woodcuts, and accompanied by an atlas of colored maps.

Geographical Surveys west of the One-Hundredth Meridian. By Lieutenant G. M. Wheeler. Pp. 355. With Illustrations. Washington: Government Printing-Office.

During the year ending June, 1876, Lieutenant Wheeler's Survey was organized in two divisions, designed to operate, the one in California, and the other in Colorado and New Mexico. The volume before us, besides the general report of Lieutenant Wheeler, and the executive and descriptive reports of the officers in charge of the California and Colorado divisions, contains several special reports by scientific men attached to the survey, among which we may mention, as possessing a direct popular interest, reports by Dr. Loew on alkaline lakes and mineral springs in Southern California, and on the physical and agricultural features of the same region; a report by Dr. Yarrow on ethnological researches made near Santa Barbara; an analysis by A. S. Gatschet of eleven Indian dialects; last, but by no means least, Lieutenant Bergland's report on the operations of a party commissioned to determine the feasibility of diverting the Colorado River for purposes of irrigation.

Precursory Notes on American Insectivorous Mammals. By Dr. Elliott Coues. (From Hayden's "Reports.") Pp. 22. Washington: Government Printing-Office.

The insectivorous mammals here described belong to two families, namely: *Talpidæ*, or moles, and *Soricidæ*, or shrews. Of moles the author recognizes four good genera as existing in America, namely: *Scalops*, *Scapanus*, *Condylura*, and *Urotrichus*. *Urotrichus* is the only one of the four known to be common to both hemispheres. Of European genera of *Soricidæ* only one, *Sorex*, is known to occur in America; *Blarina* is the most characteristic American genus. The third and last of the American genera is *Neosorex*.

Report of the Philadelphia Board of Health for the Year 1875. Pp. 351.

We have specially to commend this volume for the many neat graphic charts which it contains. Statistical tables are always dry and confusing, but when they are cast

into the shape of graphic charts even the most careless cannot fail to note the fluctuations of the quantities which they represent. Among the matters treated of in the body of the report, we would name especially the Municipal Hospital, water-supply, nuisances, as fat-boiling, intramural interments, etc. The deaths in Philadelphia for the year covered by the report numbered 17,805, an increase of 2,567 over the preceding year. The exhibit of the statistics of mortality among children under ten was less favorable than usual; the year 1872, when small-pox committed such ravages, was not as fatal to children as 1875. Diphtheria prevailed to an extent unprecedented in the records of the preceding sixteen years.

Coördinate Surveying. By H. F. Walling, C. E. Pp. 19. With Plates. (From "Proceedings of the American Society of Civil Engineers.")

The object of this essay is best stated in the words of the author himself, who says: "It is the object of this paper to point out a simple method by which the high degree of precision which accompanies the Coast Survey work may be made available in the ordinary operations of land-surveyors and civil engineers, in those districts over which the Coast Survey triangulations have been carried, and at the same time to call attention to the importance of an extension of these triangulations over the entire country."

Problem of Problems.

We noticed, not long ago, a book entitled the "Problem of Problems," a discussion of atheism, Darwinism, and theism, which has been much praised by theological authorities as an annihilating criticism of Evolution and the Darwinian school. The book received some damaging criticism, and the rumor got started that it would be revised. But it seems this is an error. Whatever else may change in this world of mutations, the "Problem of Problems" and its solution in President Braden's book will remain unchanged. The author announces in the Cincinnati *Christian Standard* that "it will never be revised." He says, "The commendations of the book have been such, and by such persons, that it would be a reflection on them to revise it." It is a great satisfaction to have something at last that will be stuck to and can be depended upon. And, now that we have something that is to stand like a lighthouse amid the storms of controversy, it is well to be fully aware of its value, and we notice that the *Journal of Speculative Philosophy*, in its April issue, testifies of the author that "for tilting against the Darwinians, Spencerians, Comtians, Correlationists, Evolutionists, *et id genus omne*, he is well enough accoutred, and is mighty in his cause." We shall do well not to forget how this puissant finality in modern polemics originated. The *Journal* says of the author, "At the age of fourteen he became a skeptic, and lectured in public on the skeptical side of the question." The precocious rogue pursued this scandalous course for ten years, when he was abruptly pulled up, and took the back track. The *Journal* says, "At the age of twenty-four he met a preacher, who converted him, and he began his career as a lecturer against skepticism, the fruits of which are contained in the volume before us." Now, if anybody wants to stop a great scientific movement, he will know how to prepare for it.

Why the Earth's Chemistry is as it is. By J. N. Lockyer, F. R. S. L. New York: Macmillan. Pp. 59. Price 25 cents.

Three lectures by Mr. Lockyer are contained in this volume; they were originally delivered at Manchester, before a popular audience. In the first of these the author gives a singularly clear account of the principles and main results of spectrum analysis of nebulæ and comets. The second lecture treats of meteorites, and the chemical constitution of the stars and the sun. The third lecture treats of the planets of our system and their atmospheres, and concludes with an exposition of the theory of evolution.

The Tailed Amphibians, including the Cæcilians. By W. H. Smith. Detroit: *Herald* print. Pp. 158.

This monograph, prepared as a thesis to be presented to the Faculty of Michigan University for the degree of Ph. D., very succinctly describes the distinguishing char-

acters of the several orders of animals belonging to the class *Amphibia*. Wherever the author had it in his power to study the characters of the animals he describes, either in living specimens or in natural history collections, he has done so; in other cases he has had recourse to the writings of the best authors. The work is one of solid merit, both for its original research and for its concise presentation of the results of prior investigation.

Principal Characters of the Coryphodontidæ; Characters of the Odontornithes; Notice of a New and Gigantic Dinosaur. By Prof. O. C. Marsh. Pp. 6. With Plates. (From *American Journal of Science and Arts.*)

A special interest attaches to the genus *Coryphodon*, inasmuch as it occurs in the tertiary strata of both hemispheres. In the second paper named above, Prof. Marsh gives certain characters common to the odontornithes with the ostrich. The third paper contains measurements of portions of a dinosaur which surpassed in magnitude any land-animal hitherto discovered, its length having been probably from fifty to sixty feet!

Topographical Atlas Sheets.

These "Atlas Sheets" are a portion of a series of maps designed to embrace the territory of the United States west of the one-hundredth meridian. The present set, seven in number, are devoted to the topography of portions of Colorado, Arizona, and New Mexico. They are based on the results obtained by Wheeler's Survey.

Iron and Steel Constructions. By J. J Weyrauch, Ph. D. Pp. 112. With Plates. New York: Van Nostrand. Price, $1.

The problems discussed in this little volume, namely, the strength and calculation of dimensions of iron and steel constructions, have for some time engaged the attention of engineers on both sides of the Atlantic. The author presents a general view of the results so far obtained, and offers formulas of his own based on Wöhler's law. The calculations have special reference to bridge and building constructions.

Gold and Debt. An American Hand-Book of Finance. By W. L. Fawcett. Chicago: S. C. Griggs & Co. Price, $1.75.

Considerable useful information, and a number of tables convenient for reference, have been gotten together in this book. The money units of the world, paper, coin, suspension of specie payments, etc., are the subjects of a series of chapters which show that the author has bestowed a good deal of labor on them. He says, however, that "the first object was the compilation in compact form, convenient for reference, of trustworthy statements and figures regarding the great factors in the financial problems of the day." There is certainly a need for such a book, but this volume hardly supplies it. The discussion of subjects too large for his space, and of others that are purely speculative, has taken up time and room that should have been used in collecting and arranging the material proper for a hand-book. Thirty-one pages, for example, are given to estimates of the amounts of gold and silver in the world—a sort of speculation that is wholly worthless. There is a lack of system in the arrangement of the tables; there are unnecessary repetitions and unaccountable omissions; and, finally, there is no index, a negligence not to be forgiven in a work of this kind. Still, it will be found convenient for the business-man and the student until a better one is prepared, which, as this is not a very remunerative field of work, may be a long time.

Ornithology of the Region about the Sources of the Red River of Texas. By Lieutenant C. A. H. McCauley. (From Hayden's "Reports.") Pp. 40. Washington: Government Printing-Office.

Lieutenant McCauley, while on sick-leave in Southern New Mexico, attached himself as a volunteer to an exploring expedition conducted by Lieutenant Ruffner, of the Engineers. His duties mainly related to the survey proper, and he was able to devote to the collection of ornithological specimens only the leisure time left after the day's work or the day's march was over. Nevertheless, he has made a substantial contribution to the avi-fauna of the region explored. The report is edited and annotated by Dr. Elliott Coues, United States Army.

PUBLICATIONS RECEIVED.

Supplemental Remarks on the Physiological Effects of Severe and Protracted Muscular Exercise, with Especial Reference to its Influence upon the Excretion of Nitrogen. By Prof. Austin Flint, Jr., M. D. From the *Journal of Anatomy and Physiology*. Pp. 9.

Some Remarkable Gravel-Ridges in the Merrimack Valley. By Geo. F. Wright. From Proceedings of the Boston Society of Natural History. Pp. 17. Maps 3.

Report on Dermatology. By L. P. Yandell, Jr., M. D. From the *American Practitioner* for June, 1877. Louisville, Ky. Pp. 8.

A New Test-Reaction for Zinc, and other Laboratory Notes. Pp. 6. And Notes upon the Lithology of the Adirondacks. Pp. 35. By Albert R. Leeds. From the *American Chemist* for March, 1877.

On the Production and Use of Compressed Air in Mining Operations. By M. F. L. Cornet. Translated from the French by Robert Zahner. From the *Journal of the Franklin Institute*, for June and July, 1877. Pp. 21.

On the Brains of some Fish-like Vertebrates; on the Serrated Appendages of the Throat of Amia; on the Tail of Amia. By Burt G. Wilder, M. D. From Proceedings of the American Association for the Advancement of Science, 1876. Pp. 11, and Plate.

The Scientist's Theology. By E. A. Beaman. New York: E. H. Swinney, 1877. Pp. 24. Price, 10 cents.

On the Use of Large Probes in the Treatment of Strictures of the Nasal Duct. By Samuel Theobald, M. D. From the Transactions of the Medical and Chirurgical Faculty of Maryland. Baltimore, 1877. Pp. 22.

Report of the Director of the Central Park Menagerie, for 1876. New York, 1877. Pp. 34.

Facts and Figures for Mathematicians; or, The Geometrical Problem which Benson's Geometry alone can solve. By Lawrence S. Benson. New York: 149 Grand St. Pp. 22. Price, 30 cents.

On the Possibility of Transit Observations, without Personal Error. By S. P. Langley. From *American Journal of Science and Arts*, July, 1877. Pp. 6.

Report on the Discovery of Supposed Paleolithic Implements, from the Glacial Drift in the Valley of the Delaware River, near Trenton, N. J. By Charles C. Abbott, M. D. Cambridge, 1877. From Tenth Annual Report of the Peabody Museum. Pp. 14. Illustrated.

Address delivered by Hon. A. J. Peeler, before the State Agricultural and Mechanical College of Texas, June 26, 1877. Austin. Pp. 34.

The Pneumatic Electric System for lighting and extinguishing the Gas used for Street-Lights, and the Use of the Apparatus for General Telegraphic Purposes. By John H. Blake. Boston, 1877. Pp. 33. Illustrated.

The National Guardsman. A Journal devoted to the Interests of the National Guard of the United States. Vol. i., No. 1. August, 1877. Monthly. Pp. 16. Price, $1 a year.

Thirty-third Annual Catalogue of the Officers, Faculty, and Students, of the University of Notre Dame, Indiana, for the Academic Year 1876–'77. Pp. 62.

Remarks of Robert E. C. Stearns on the Death of Colonel Ezekiel Jewett; and also on the Late Dr. Philip P. Carpenter. Before the California Academy of Sciences. Pp. 5, each.

The Magnetism of Iron Vessels, with a Short Treatise on Terrestrial Magnetism. By Fairman Rogers. New York: D. Van Nostrand, 1877. Pp. 125. Price, 50 cents.

Art-Education applied to Industry. By George Ward Nichols. With Illustrations. New York: Harper & Brothers, 1877. Pp. 211. Price, $4.

The American Palæozoic Fossils. A Catalogue of the Genera and Species, etc. By S. A. Miller. Cincinnati, 1877. Pp. 253. Price, $3.

Mesmerism, Spiritualism, etc. By William B. Carpenter, LL. D., F. R. S. New York: D. Appleton & Co., 1877. Pp. 158. Price, $1.25.

The Question of Rest for Women during Menstruation. By Mary Putnam-Jacobi, M. D. The Boylston Prize Essay of Harvard University for 1876. Illustrated. New York: G. P. Putnam's Sons, 1877. Pp. 232. Price, $3.50.

POPULAR MISCELLANY.

Death of Prof. Sanborn Tenney.—We have learned with regret of the death of Prof. Tenney, which took place on July 9th, at Buchanan, Michigan. The sad event was unexpected, as the deceased had, one week previously, seemed to enjoy perfect health. The cause of death is supposed to have been heart-disease. From an appreciative biographical sketch of the deceased which has appeared in the *New York World* we gather the following particulars about his scientific labors: In 1868 he was Professor of Natural History in Vassar College, and in the same year accepted a like position in Williams College. He had already published an elementary text-book of geology, which is still, after repeated revisions, largely used in high-schools and academies. He was a frequent contributor to periodical literature of scientific articles of a popular kind. The present number of the MONTHLY contains probably the latest essay of this description written by him. He was an enthusiastic and careful student, a pupil and admirer of Agassiz, and like his distinguished preceptor he excelled as a teacher. Besides the "Geology" mentioned above, Prof. Tenney compiled several other popular text-books, among them one on zoölogy. He occupied the chair of Natural History in Williams College down to the time of his death. He was to have been in charge of an expedition of college-students to the far West this season, and on the day he died was to have joined the expedition at Chicago.

Remains that were not prehistoric.—We have received from a source unknown to us two clippings, from the *Weekly Press*, presumably of Santa Barbara, California, in

which mention is made of the result of excavations in "the Carpenteria." These excavations led to the discovery of a large mass of human bones, domestic implements, trinkets, and other objects, which were at first supposed to be "prehistoric." The ardor of the explorers was, however, much dampened when they found among the treasure-trove such modern articles as glass beads and glass wine-bottles, and the conclusion was inevitable that the curiosity-seekers had simply struck "a big graveyard of the native population, whom the missionary *padres* found and taught here eighty or one hundred years ago." A letter of inquiry having been addressed to Mr. Hubert H. Bancroft, author of "The Native Races of the Pacific States," that gentleman expressed in the following terms his opinion of the supposed prehistoric character of the Carpenteria "find:"

"There is no evidence whatever in California of a race older or more civilized than that found by Europeans a century or so ago. In Mexico and Central America the case is very different. There are a few material remains in Northern Mexico, Arizona, and New Mexico, but nothing, so far as I have been able to discover, north of these points."

Rare Minerals in Colorado.—Writing of rare minerals found in Colorado, Mr. T. F. Van Wagenen, in the *Engineering and Mining Journal*, says that thallium, indium, and cadmium, have lately been detected in ores from that State. Of the rarer metals there have been found in Colorado, besides the three mentioned above, nickel, cobalt, selenium, tellurium, uranium, bismuth, molybdenum, and platinum, and there is scarcely a doubt that columbium, thorium, titanium, and vanadium, will be recognized as soon as proper search is made. A belt of tellureted veins is believed to traverse the entire State from north to south. Two years ago, sylvanite and altaite were found in San Juan County. The principal locality for bismuth-ores is in Geneva, where two mines are being worked that carry a considerable quantity of schirmerite. Sulphide and carbonate of bismuth occur on Sugarloaf Mountain, Boulder County. Nuggets of native bismuth are common in the upper gulches of the Blue Valley; the same metal has been found also in the Arkansas Valley. Nickel-ore, ranging from two to five per cent., has been found in three localities. Among the mineralogical curiosities of the tellurium belt may be mentioned a telluride of mercury found in the Mountain Lion mine. Native mercury and amalgams of both gold and silver have also been found at several points along this belt.

The Vienna Scientific Club.—In January, 1876, the project of founding a Scientific Club in Vienna was considered at a meeting of the Geographical Society of that city. It was very favorably received by the members, and measures were taken to carry it into execution. Before many weeks the club was organized, and suitable quarters provided for it in the house occupied by the Austrian Association of Engineers and Architects. There the club finds ample accommodation for the social gatherings of its members, as also for its regular Thursday-evening meetings for scientific discussion, and its more public entertainments. In March, the number of members was nearly 700, and it was steadily increasing. The yearly dues of members of the club amount to only sixteen florins—less than eight dollars—and there is an entrance-fee of five florins. The club has a growing library and reading-rooms, with a very large number of periodicals, scientific and literary, on file. If such clubs as this, and equally inexpensive, were founded in our large American cities, they would afford a much-needed means of communication between workers in different branches of science. Further, they would give something like organization to the body scientific, and perhaps add weight to scientific opinion.

Steel-Bronze Cannon.—Uchatius's invention of "steel-bronze" cannon rests, says *Nature*, on the observation that all metals (lead and zinc excepted) gain an increase of elasticity, after undergoing a continuous weighting above their first limit of elasticity. Later experiments by the inventor of the steel-bronze cannon appear to show that even homogeneous bronze is capable of a great increase of its elasticity through simple stretching without condensation. It is only a stretching of the metals above

their limit of elasticity, whereby the molecules, brought to a state of flow, glide over each other, and assume a wholly new position more favorable to resistance, that causes the increase of elasticity. A simple condensation produces merely an increase of the absolute solidity and diminution of the tenacity, but no real increase of elasticity. The limit of elasticity may be raised nearly to the breaking consistence, so that, in many cases, it is six and seven times the original. Mere stretching for a short time is of little use; the tension must last a considerable time. It is also well to apply a gradually-increasing weight.

Properties of White Paint.—As the result of hundreds of experiments in carbonate of lead and hydrate of lead, both separately and mixed, Messrs. Wigner and Harland, of the British Society of Public Analysts, reach the conclusion that a white paint, to be efficient, and to possess both the powers of laying on readily and easily, and by its opacity hiding the color beneath, must consist of an admixture of hydrate and carbonate of lead in a certain definite proportion. The true proportion would appear to be three equivalents of carbonate of lead and one equivalent of hydrate. The experiments further show why zinc-white, carbonate of magnesia, and other metallic oxides and carbonates, do not yield good paints. In the case of white-lead a positive chemical compound has been formed, and the seventy-five per cent, or thereabouts, of carbonate of lead present has been dissolved in the chemical compound, and so a paint has been formed which possesses a covering power in excess of any other compound known. Until some means can be devised by which oxide of zinc or some other substance can be dissolved in the same way, so as to form a paint possessing characters somewhat different from a mere emulsion, it is vain to expect that they can equal good white-lead.

Change of Tint in Flowers.—The change of tint in flowers of *Ipomoa purpurea* (morning-glory) under the influence of atmospheric moisture was the subject of a communication by Prof. D. S. Martin to the New York Academy of Sciences. The phenomenon was observed in dark-blue flowers of this plant, and it was found to occur under two aspects, viz., 1. A reddening of the general blue color when the air is charged with moisture; and, 2. The production, by drops of rain, of sharply-defined spots upon the blue, which are at first red, and then bleach to white. Prof. Martin was led to examine the subject experimentally, by testing the flowers with acids and with ammonia-water. The result was such as was to have been expected with vegetable blues, that is to say, the ammonia had no effect, while the solutions of acids (oxalic, tartaric, and carbolic) produced the red coloring easily. Tried upon the pink variety of flowers, the acids had no effect, and the ammonia produced a strong blue color, which ere long passed away by evaporation. It is therefore evident, the author concludes, that this effect is due to some acid substance dissolved or absorbed by atmospheric water. If the latter is diffused through the air without precipitation, a general reddening of the blue corollas appears; if it falls upon them as rain and stands for a while, every drop produces a sharp spot that passes from red to white.

Barff's Method for preserving Iron.—A method proposed by Prof. Barff for preventing the corrosion of iron consists in producing upon the surfaces of the iron articles to be protected a coating of the black or magnetic oxide of iron. This he does by raising the iron articles, in a suitable chamber, to a temperature of from 500° to 1,200° Fahr., and then passing steam into this chamber, keeping the articles for five, six, or seven hours, as the case may be, at that temperature, in an atmosphere of superheated steam. At a temperature of 1,200° Fahr., and under an exposure to superheated steam for six or seven hours, the iron surface becomes so changed that it will stand the action of water, even though it be impregnated with the acid fumes of the laboratory. When the process is carried on at a lower heat, the iron articles will resist any amount of moisture with which they may come in contact in a house or building; but they will not permanently resist the action of the weather out-of-doors. The reason of this is, that only a thin film of the

iron, on its surface, is transformed into the black oxide. Iron pipes protected by this process may be used instead of lead pipes for conveying water through houses. Iron for architectural uses may be made to resist the weather; the process may also be employed to protect cast-iron statues, which would thus be rendered as enduring as those of bronze.

The Mystery of Pain.

BY PROFESSOR GRANT ALLEN.

On the crimson cloth
  Of my study-desk
A lustrous moth
  Poised, statuesque.
Of a waxen mould
  Were its light limbs shaped,
And in scales of gold
  Its body was draped;
While its delicate wings
  Were netted and veined
With silvery strings
  Or golden-grained,
Through whose filmy maze
  In tremulous flight
Danced quivering rays
  Of the gladsome light.

On the desk close by
  A taper burned,
Toward which the eye
  Of the insect turned.
In its vague little mind
  A faint desire
Rose undefined
  For the beautiful fire.
Lightly it spread
  Each silken van.
Then away it sped
  For a moment's span;
And a strange delight
  Lured on its course,
With resistless might,
  Toward the central source,
And it followed the spell
  Through an eddying maze,
Till it staggered and fell
  In the deadly blaze.

Dazzled and stunned
  By the scalding pain,
One moment it swooned,
  Then rose again:
And again the fire
  Drew it on with its charms
To a living pyre
  In its awful arms:
And now it lies
  On the table here
Before my eyes
  All shriveled and sere.

As I sit and muse
  On its fiery fate,
What themes abstruse
  Might I meditate!
For the pangs that thrilled
  Through its delicate frame,
As its senses were filled
  With the scorching flame,
A riddle inclose
  That, living or dead,
In rhyme or in prose,
  No seer has read.
"But a moth," you cry,
  "Is a thing so small!"
Ah, yes, but why
  Should it suffer at all?
Why should a sob
  For the vaguest smart
One moment throb
  Through the tiniest heart?
Why, in the whole
  Wide universe,
Should a single soul
  Feel that primal curse?
Not all the throes
  Of mightiest mind,
Nor the heaviest woes
  Of humankind,
Are of deeper weight
  In the riddle of things
Than this insect's fate
  With the mangled wings.

But if only I,
  In my simple song,
Could tell you the *why*
  Of that one little wrong,
I could tell you more
  Than the deepest page
Of saintliest lore,
  Or of wisest sage:
For never as yet
  In its wordy strife
Could Philosophy get
  At the import of life;
And Theology's saws
  Have still to explain
The inscrutable cause
  For the being of pain:
So I somehow fear
  That, in spite of both,
We are baffled here
  By this one singed moth.

Prof. Hebra on the Use of the Bath.—Prof. Hebra, of Vienna, dissents from the generally-received opinions as to the benefits of frequent resort to the bath. His views on this subject, as set forth at some length in the *Boston Journal of Chemistry*, are to the following effect: It is not true that frequent bathing is conducive to health, and harmless: millions of men take no baths of any kind, at most only washing the face and hands, and yet live to old age in good health. It cannot be proved that

the use of the various kinds of baths wards off disease, or that washing in cold water prevents catarrh, rheumatism, etc. As long as "water manipulation" is accompanied by an agreeable general sensation and no eruption on the surface of the skin occurs, it may be pursued as a pastime; but when it produces great itching or eruption on the skin, the bathing and washing must cease. The consequences of friction, douches, hot vapor, shampooing, etc., sooner or later show themselves in the shape of permanent redness, a sensation of burning or itching, and the production of nodules and furuncles, which precede the formation of pustules and abscesses. Prof. Hebra speaks as follows of the employment of water in the treatment of skin-diseases:

"Its employment is *contraindicated* in all sensitive, irritable persons whose skin is liable to prolonged redness, the production of rashes, and itching; in all cutaneous affections accompanied by acute swelling and serous infiltration; and in all chronic dermatoses in which the horny layer of the epidermis—either through the effects of disease or of remedies—has been removed, exposing the layer beneath. Thus it is not proper to employ water soon after using stimulating substances externally, as arsenic, iodic mercury, etc. By avoiding water and employing starch or other inert powder, the healthy state of the surface will be much sooner restored. Water, on the contrary, is *indicated* in those diseases where its macerating and irritating effects are useful, namely, in chronic dermatoses, such as psoriasis, lichen, ichthyosis, old eczema, prurigo, etc. Water also exerts the most beneficial effects when different secretions—the products of inflammation, and the remains of dead tissue—have to be removed, as in abundantly-suppurating wounds, ulcers, and gangrene. It is useful also in favoring the formation of new epidermis in pemphigus, and after extensive destruction of the skin by burns or caustic substances."

Domestication of the Wild-Turkey.—The following observations on the habits and domestication of the wild-turkey we take from a paper of similar title by J. D. Caton, published in the *American Naturalist*. Mr. Caton commenced domesticating the wild-turkey about ten years ago, his original stock having been procured from the eggs of the wild hen; it has been twice replenished in the same way. The young birds from the wild-turkey's eggs, when brought up in close intimacy with the human family, become very tame, but they are afraid of strangers, and when anything excites their suspicion they take wing and are off like a flock of quails. The young turkeys breed freely when a year old. Mr. Caton is now raising the eleventh generation of the domesticated wild-turkey, and says that the breed has not deteriorated either in size or in reproductive powers. But they have changed in form and in the length of the legs; the body is shorter and more robust, and its position is more horizontal. As regards color but little change was observed in the first or second generation; after that, the tips of the tail-feathers and tail-coverts began to lose the soft chestnut-brown of the wild-turkey, and to become lighter; the changeable purple tints of neck and breast assumed a greenish shade; the bristles on the naked portions about the head became more sparse or altogether disappeared; the blue about the head and the purple of the wattles became bright-red; the pinkish-red of the legs became dull or changed to brown. These changes of color were seen in the first year of the bird's growth, but in its second these marks of degeneration would in most individuals, especially the cocks, disappear, and the plumage would show the thorough-bred wild-turkey. Each succeeding generation shows these changes to be more pronounced, but each year as the bird grows older the shades of color of the wild parent become more distinct. But Mr. Caton has hens now three or four years old with brown legs and on whose feathers the white has very considerably superseded the cinnamon shade, and he is satisfied that without a fresh infusion of wild blood in the course of fifteen or twenty years more but few individuals would show the distinctive marks of the wild-turkey to any considerable extent.

The habits of the wild-turkey are not so rapidly changed as the form and coloring, still they too change. The wild-turkey cock by the time he is five months old seeks

a perch well up in the largest trees in his range, and as he grows older he is disposed to roost higher and higher, till he is frequently found at the very apex of the tallest tree. This habit is scarcely impaired by domestication in the second and third generations, but after that the birds grow less and less ambitious of high places, till at last they come down to about the level of the domestic turkey. The timidity characteristic of the wild-turkey is eradicated very slowly. When the wild-turkey in the forest voluntarily leaves her nest, she always covers it carefully with leaves. This is done with less care by the first descendants of the wild hen, and each succeeding generation becomes more careless in this respect.

Prof. Thurston on our Domestic Metals.—The statement is made by Prof. Robert H. Thurston that this country has for years been importing cast-iron, while domestic products of equal and even greater intrinsic value sell at lower price. Other similar instances of unwisdom are cited by Prof. Thurston, as, for example, the fact that we are importing boiler-plate at eleven cents a pound, when we can purchase American steel, vastly superior in all respects for the special purposes to which the former article is applied, at eight cents. Again, we import vast quantities of foreign steel tools, when at Pittsburg and elsewhere we make steel fully its equal. In New England and Pennsylvania we have ores from which is made the finest cast-iron ordnance in the world. In Ohio we make a metal for car-wheels such as is never seen in Europe, and of such tenacity and elasticity that foreign engineers listen incredulously when it is described. Our Lake Champlain ores make an iron fully equal to Swedish for conversion into steel; and around Lake Superior and in Missouri we have deposits from which comes Bessemer metal far superior to the phosphorus-charged metal we import. New Jersey supplies us with zinc which meets with no competition as a pure metal, and which can be used without purification even for chemical purposes; and our native copper is absolutely free from admixture with injurious elements. It is time that these facts should be known, and that the people should disabuse their minds of the idea that, because a commodity is "imported," it is therefore of greater intrinsic value than a domestic product.

The Deterioration of Silk Fabrics.—The complaint is frequently heard that the silk fabrics now manufactured are by no means as lasting as similar fabrics manufactured twenty or thirty years ago. That this complaint is justified, the *Warehouseman and Draper* admits, and then points out the causes of the deterioration. Adulteration of silk on a large scale, and systematically, began about eighteen years ago, soon after the silk-worm disease had made its appearance in the silk-producing countries of Europe, when raw silk rose from twenty-one and twenty-two shillings sterling per pound to as much as sixty shillings. In order to keep down the price of the manufactured goods, foreign materials were introduced, and these were often in excess of the silk. "It would be curious," says a writer on the subject of "weighting" silks, "to follow one pound of China or Italian silk through its various processes in reaching a silk dress. The silk is sent to the dyers, and the first process is boiling off. All silk in its natural state has a certain amount of gum in it; this must be boiled off, and, when this is done, sixteen ounces are reduced to twelve. It is then dyed black, and the process of weighting commences. The twelve ounces is sent to the manufacturer, varying from twenty-four to fifty-two ounces. I have to-day seen silk dyed and weighted in Lyons up to fifty-two ounces. Very large dye-works exist in Lyons for the purpose of doing this business; and it is done to perfection."

Fatality of Inebriety.—In an article on the "Duration, Mortality, and Prognosis of Inebriety," by Dr. T. D. Crothers, published in the *Quarterly Journal of Inebriety*, we are informed that the mortality of this disease has been estimated at from 96 to 98 per cent., or less than *four per cent of recoveries*. Under treatment in asylums the lowest estimate has been placed at 33 per cent., and from that up to 62 per cent. This excessive mortality is due, according to Dr. Crothers, to profound degenerations, produced by alcohol, and the peculiar conditions of low vitality, impaired and per-

verted cell-action, commonly preceding this disorder. The inebriate is literally in a toxic condition, in which all the organs are both unduly depressed and exalted, or in a state of suspended activity, bordering on paralysis. The mortality of the inebriate is further increased by the favoring conditions which bring on inflammatory affections, as pneumonia, pleurisy, gastritis, diseases of the kidneys, etc. Severe bodily injuries, too, have generally a fatal termination in inebriates. The existing degenerations seem to intensify the lesion and its effect, and reduce the resisting power of Nature to its minimum. The fatality of inebriety is increasing, and its complications are becoming more profound and general.

Uses of the Antennæ of Insects.—In working on the problem as to the use of the antennæ of insects, Mr. L. Trouvelot, as he states in the *American Naturalist*, procured a large number of butterflies of *Limenitis disippus*, and with about a dozen of these tested the truth of a statement to the effect that a butterfly deprived of its antennæ, on being thrown up into the air, falls heavily to the ground without spreading its wings. All these butterflies took flight, but there was a certain hesitation in their movements. The author next carefully covered with thick Indian-ink the eyes of several individuals; when this coating was dry they were allowed to go free. They could fly, and, though blind, avoided hurting themselves by dashing against any hard object. Both antennæ having been cut off from a blinded butterfly, the insect when thrown up fell heavily. Another butterfly, blinded and with antennæ removed, was set at liberty on a table. Then with a small brush a drop of sweetened water was held very near the mouth, head, spiracles, etc. The insect remained perfectly still; but, when the stumps of the antennæ happened to be touched, it unrolled its proboscis and searched for the sweet liquor. The next insect was treated like the last, save that a drop of thick gum-arabic was allowed to dry on the stumps of the antennæ. The insect could not use its wings, and was insensible to the touch of sugar-water on the sealed stumps. Experiments showed that insects deprived of their antennæ do not copulate. The author next cut off the antennæ of ants, and then let them go free with their comrades; these mutilated ants did not seem to recognize their fellows, nor did they follow the same path, but kept moving in a circle. The author, in summing up the results of his experiments, says that the sense located in the antennæ is not merely that of touch, hearing, or taste, nor a combination of all these: it appears to differ essentially from any of man's senses; it is a "kind of feeling or smelling at a great distance."

Moss-Copper.—The term "moss-copper" is used to designate accumulations of filamentous copper found in cavities, in pigs of certain kinds of regulus. This moss-copper appears to be formed at a comparatively low temperature, and it has actually been produced at a temperature far below redness, by W. M. Hutchings, who gives in the *Chemical News* an account of his interesting experiments. He fused a button of regulus, one-quarter of a pound in weight, under borax in a clay crucible, and then poured the molten mass into an iron mould. After it had cooled in the mould for some time, so that it had been quite solidified for some minutes, it was broken in two by a blow with a hammer. It had now cooled below redness, even in the centre. At the moment of fracture the surfaces exposed were perfectly clean and lustrous, but after a minute or two they became slowly covered with a growth of minute copper filaments, which increased till in some places it resembled a coarse velvet. After three or four minutes one of the halves was again broken in two, and again the exposed surface was lustrous. The piece was now just cool enough to hold in the hand, yet the moss-copper slowly began to appear here also, though not so abundantly as before, and only in patches.

Fauna and Flora of the Florida Keys.—L. F. de Pourtalès, in *The Naturalist*, signalizes the Florida Keys as a curious example, though on a very small scale, of a land of comparatively modern origin, which has received its fauna and flora from two different and very distinct sources—the West Indies and the North American Continent—

the flora being derived chiefly from the former, and the fauna mostly from the latter. The marine fauna of the coral region of South Florida he pronounces a West Indian colony engrafted on the more or less North American fauna of the east and west coasts of the peninsula. Of the land animals the mammals are entirely North American. The batrachia and reptiles, too, belong, with a very few exceptions, to North American species. The insects are probably of mixed origin, coming from North America, Cuba, and the Bahamas. The land-shells of the Keys are the same as those of the mainland.

As regards the flora of Florida and its Keys, the author says of the pine that it is confined to the mainland, there being only one small group of Keys which bears a growth of pines. Pine-forests, indeed, are characteristic of the shores of Florida, and of all the Southern States, while the characteristic trees of the Keys are fig-trees, quassia, torch-wood, mahogany, and a few others, interspersed with a dense shrubbery, in which several species of *Eugenia* are perhaps most common.

How the American Aborigines disposed of their Dead.—The modes of disposing of the bodies of the dead in use among the aborigines of America are classed by Mr. Edwin A. Barber, in the *Naturalist*, under four heads, viz.: inhumation, cremation, embalmment, and aërial sepulture. Of these, the first was most usually employed, the bodies being interred either in ordinary graves, in mounds, or in caves. Several tribes, among them the Lenni-Lenape, or Delawares, were accustomed to incase their dead in stone boxes or tombs. In tumulus-burial, the dead were generally laid near the original level of the surface, and the mound heaped over them. Only isolated instances of cave-burial have been signalized in the United States, as in Breckenridge County, Kentucky, and in the Cañons of Utah, Arizona, and New Mexico. Cremation was of two kinds—in graves and in urns. Among the Pueblos of Arizona and Utah the body was sometimes burned, and the ashes deposited in shallow tombs. Several tribes on the Gila River, in Southern Arizona, burned the bones of the dead in urns. But few cases of embalming are known to have occurred in the limits of the United States. As examples of this mode of preparing the corpse may be mentioned the Mammoth Cave and Salt Cave mummies of Kentucky. These bodies have been preserved by a rude species of embalmment and by exsiccation. Aërial sepulture was of two kinds—the first by suspension on scaffolds or in trees, the second by sepulture in canoes. Several tribes still employ the former mode of burial. The Sioux elevate the bodies of their dead into trees, or stretch them out on raised platforms, wrapping them in blankets and leaving them to the mercies of the elements and carnivorous birds.

Accurate Geological Estimates.—A good illustration of the exactness of modern geological science is found on comparing the results actually obtained in the sinking of artesian wells in London with the conclusions reached by Prof. Prestwich as long ago as 1851. In a work published in that year, "A Geological Inquiry respecting the Water-bearing Strata of the Country around London," Prestwich made the prediction that the chalk beneath London would be found to have a thickness of 650 feet, the upper green-sand of 40 feet, and the gault of 150 feet. At the time of this announcement, as we learn from *Nature*, no well in London had been sunk to a greater depth than 300 feet in the chalk, but now there are four deep borings which marvelously confirm Prof. Prestwich's reasonings. We take from our London contemporary the following table, showing the results as calculated by Prestwich, and as actually ascertained by borings:

STRATA.	Prestwich's Estimate.	Boring at Kentish-town.	Boring at Crossness.	Boring at Meux's Brewery.
Chalk............	650	645	646	653
Upper green-sand.	40	13½	12	28
Gault............	150	130½	148	159

"When it is remembered," adds *Nature*, "that the chalk graduates downward insensibly into the upper green-sand, and that it is almost impossible to decide on their line of separation, it will be admitted on all hands that the agreement between the estimated and proved results is marvelously close."

Mental Disease in Animals.—The pathology of mind in the lower animals, and more especially in domestic animals, is a subject which, singularly enough, has hitherto attracted very little attention, though it is one that ought to possess the highest interest to man. Dr. W. Lauder Lindsay, who for a few years past has devoted himself to the study of mental phenomena as exhibited in the animal creation inferior to man, contributes to the *Journal of Mental Science* the results of his observations upon the mental pathology of animals, from which it appears that in them insanity is virtually the same as in man. He notes, however, certain peculiarities in the case of the lower animals, the most important of which is the facility with which *artificial insanity* may be produced in them, either by ill-usage or by brain or blood poisoning; hence the whole course of insanity may be very conveniently studied in animals. This unworked field of comparative psychology presents to the ambitious young physician the opportunity not only of earning distinction, but also of adding to human knowledge, and thereby to human as well as animal happiness and well-being. "Let me," writes Dr. Lauder Lindsay, "commend the experimental and scientific study of the pathology of mind in the lower animals to those capable youths who at present fritter away their time, temper, and opportunities, on subjects both trite and trivial; who expend their ingenuity in improving upon Nature by drawing hard and fast lines of demarkation where she draws none; who discover in the last fashionable drug, or mode of drugging, a panacea for all the ills of the insane; who delight in barren statistics that have already been tabulated a thousand times, with results of no practical value."

Archæology.—The Lapham Archæological Society of Wisconsin is the name of an organization formed and located at Milwaukee, Wisconsin, for the purpose of instituting researches into the antiquities of that State. It proposes to survey and register the discovery of ancient mounds; collect and preserve the relics found; and to publish from time to time such information concerning the results of its labors as will lead to a better knowledge of the origin and character of the prehistoric peoples of the region of the Great Lakes and the Mississippi Valley. It has long been known that Wisconsin is particularly rich in remains of the mound-builders. In 1855 Dr. J. A. Lapham, after whom this society is fitly named, published, as one of the Smithsonian contributions, a quarto volume describing and figuring such as had then been observed. They have been discovered in great numbers since, and there is ample room for vigorous work in exploring and describing them before they disappear under the denuding operations of the plough and the harrow. They are so widely scattered and so small in size that their preservation is quite out of the question after the soil begins to be cultivated. It is to be hoped that the society will be able to push its labors successfully, and that its action may excite a spirit of emulation in other localities.

NOTES.

A destructive tornado visited the vicinity of Elkhart, Indiana, on the afternoon of July 2d. It completely destroyed several buildings, and unroofed others, uprooted whole orchards, and distributed trees and rubbish over acres of crops. The progress of the storm was from west to east; but the buildings and trees all fell toward the south, as if they had been taken up by the northern portion of the whirling column, and thrown into the centre, which seemed south of the principal track of devastation. No one was killed outright, but one of the injured has since died. A correspondent suggests one fact connected with the work of this tornado, which he thinks seems to indicate the presence of a large amount of electricity, if, indeed, the manifestation was not chiefly electric. All the leaves on the trees, all the corn, grain, and other green things within the path of the hurricane, were seared and shriveled, as if by great heat.

It has been found by Müller, of the Berlin Chemical Society, that steam at ordinary pressure, when sent into saline solutions, raises their temperature considerably above its own. A solution of common salt, so concentrated as to have its boiling-point 127°, may be raised to 125°, by sending into it steam at 100°. The more concentrated the solution the higher the rise.

The power of resistance to the action of sea-water possessed by copper and phos-

phor-bronze respectively is shown by the result of an experiment made under the auspices of the Russian Government. The experiment lasted for six months, and at the end of that time it was found that the copper (which was of the best quality) had lost over three per cent. of its weight, while the loss of phosphor-bronze was but little over one per cent.

In a lecture-room experiment suggested by M. V. Meyer for showing increase of weight by combustion, a candle is attached to each pan of a balance, and above one a glass tube open at both ends is hung at nearly the height of the wick. In this tube is a piece of wire gauze holding fragments of caustic soda; after balancing the candles, one of them is lit, when the products of combustion are retained by the soda, and this end of the beam descends.

That toads will eat bees, would seem to be clearly proved by the observations of M. Brunet. As the bees of a hive were crowding in to escape from a rain-storm, some of them rested on the grass in the vicinity awaiting their turn to enter. M. Brunet saw a toad busy in devouring these bees. He carried the toad again and again to a distance of from thirty to fifty metres from the hive, but sooner or later the animal was at his post again, greedily devouring the bees.

While investigating the hygienic properties of pine and eucalyptus, Charles T. Kingzett found that by exposing a mechanical mixture of water and turpentine to a current of air at normal summer temperature, a solution containing hydrogen peroxide—a powerful disinfecting and oxidizing agent—and camphoric acid may be readily obtained. This solution contains no oil of turpentine, is non-poisonous, and without harm to textile fabrics.

It is noted as a curious fact by Sir Samuel Baker that a negro has never been known to tame an elephant or any wild animal. The elephants employed by the ancient Carthaginians and Romans were trained by Arabs or Carthaginians, never by negroes. A person might travel all over Africa, and never see a wild animal trained and petted. It had often struck Sir Samuel as very distressing that the little children never had a pet animal; and, though he had often offered rewards for young elephants, he had never succeeded in getting one alive.

At the meeting of the American Medical Association, at Chicago, on June 5th, the subject of the revision of the American Pharmacopœia, the proposed rejection of the one in use, and the substitution therefor of an entirely new, more modern and complete work on that subject, was postponed indefinitely.

The long-talked-of plan of heating a city by steam, generated at one or more points, and distributed by pipes, is at length about to be practically tried at Lockport, New York, where boilers and boiler-houses are now erected. The working of this new system will be watched with interest. The inventor estimates that the saving to each householder will be from thirty-three to fifty per cent. of the present expense for stoves, coal, etc.

Remains of an enormous dinosaur have been discovered in Colorado, and received at Yale College, which, according to Prof. Marsh, would indicate the length of the entire animal to have been about fifty or sixty feet! Portions of the sacrum and of the posterior limbs have been preserved; the last two vertebræ are nearly complete. From all the indications, Prof. Marsh concludes that it was an herbivorous reptile, and perfectly distinct from any species known. He names it *Titanosaurus montanus.*

From a study of no less than a hundred and six epidemics of typhoid fever, Jaccoud reaches the conclusion that the disease is engendered by fecal matter; but that this matter is not typhogenic, that is, does not of itself produce the typhoid symptoms, unless it incloses the specific poison of the disease. There are, however, he admits, circumstances under which such matter is poisonous, without having had any previous admixture of typhoid substances. In such cases the poison is, he says, elaborated in the fecal matter, which itself, as before, is merely an agent of transmission.

In 1861, 1,500,000 pounds of Indian tea was consumed in the British Isles; three years later the amount of this tea consumed was 2,500,000 pounds; in 1867, 6,000,000 pounds; in 1870, 13,500,000 pounds; in 1874, 21,000,000 pounds; in 1875, 17,500,000 pounds; and in 1876, 19,000,000 pounds. It is expected that the consumption for the present year will be not less than 32,000,000 pounds, or one-fourth of all the tea consumed in the United Kingdom. Indian tea has always commanded the highest price in the London market.

In testing the comparative explosiveness of nitro-glycerine, in the crystallized and the liquid state, Beckerhinn used a drop-block of wrought-iron weighing 2.130 kilogrammes, having at its lower end a hardened steel point of 7.068 square millimetres. The nitro-glycerine was spread in a thin layer on a flat anvil of Bessemer steel, and the weight was dropped from different heights. The liquor exploded at a fall of 0.78 metre, but the crystallized or frozen nitro-glycerine only at 2.13 metres.

WILLIAM STANLEY JEVONS.

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BATHYBIUS AND THE MONERS.[1]

By Professor ERNST HAECKEL.

"BATHYBIUS, about which so much has been said, has no existence; the assumption of its existing rested on illusions. It will be the same with the rest of the Moneres; these supposed primordial organisms, too, will prove to be the product of erroneous observation. So has one of the main supports of the modern development doctrine fallen, and it will yet be found that all its other supports rest upon illusions and on error. The whole fabric of Darwinism is simply an air-castle, the theory of natural selection is a soap-bubble, and the doctrine of descent is not true."

Such is the gist of many an article published during the past year in all sorts of periodicals. Simply and solely from the supposed non-existence of Bathybius it is rashly inferred that there is no such thing at all as Moneres, and that the doctrine of evolution is badly hit. This assertion is of course made with most gusto by the opponents of the development theory. The clergy is already rejoicing over the utter downfall of the theory of descent. But even among the adherents of the theory of evolution, the non-existence of Bathybius is held to be proved, and from this fact a series of conclusions is drawn which suggests more or less weighty objections against some of the main principles of Darwinism. These circumstances, as also the confusion of the public mind as to the actual state of the case, have induced me to consider the Moneres question with special reference to Bathybius. It would appear to be specially my right, nay, even my duty, to discuss this question, inasmuch as it was my dubious luck to have stood godfather to this "ill-famed primordial slime of the sea-depths." When, in 1868, my friend Thomas Huxley gave

[1] Translated from the German, by J. Fitzgerald, A. M.

to it in baptism the name *Bathybius Haeckelii*, he of course could not have foreseen that the poor neophyte would, like another Icarus, in a very short time become a biological celebrity, ascending to the heaven of terrestrial fame, and then before the end of its first decennium tumbling down into the gloomy Hades of mythology. Let us see, then, whether it is really dead, and whether it has ever existed at all. And supposing we have to admit its merely mythological apparition-existence, let us see what consequences result for the Moneres.

I. *History of the Moneres.*—In the spring of 1864 I observed in the Mediterranean, at Villafranca, near Nice, little floating globules of slime, one millimetre or half a line in diameter, which interested me very much. Under the microscope each of these globules looked like a little star, its centre consisting of a far smaller, structureless globule, while from the outer surface radiated several thousand exceedingly fine threads. Close examination with high powers showed that the whole body of the star-shaped thing consisted of simple albuminous cell-substance—*sarcode*, or *protoplasm*; and that the threads radiating on all sides from the surface were not permanent organs, but constantly variable, in number, size, and shape. They were seen to be changing and non-persistent processes of the central protoplasmic body, like the "false feet," or pseudopodia, which constitute the only organs of the Rhizopods. But while in the Rhizopods cell-nuclei are scattered through the protoplasm, and hence their bodies, morphologically considered, are made up of one or of many cells, nothing of the kind is to be seen in the protoplasmic globules observed at Villafranca. For the rest, no difference was to be found between the two with respect either to the motions of the filaments or to the manner in which they were employed as organs of touch for sensation, or as organs of nutrition for taking in food. To complete the natural history of the little protoplasm-globule, which I had studied with great minuteness, all that was still needed was a knowledge of its mode of propagation. In this, too, I was finally successful. After some time the little creature broke up into two halves by simple division, and each of these went on living like the original one. Thus I had learned the whole life-cycle of what I had to regard as one of the simplest organisms conceivable, and I gave it, in recognition of its fundamental significance, the name of *Protogenes primordialis*, "first-born of primeval time." An accurate description of it was published by me in vol. xv. of the *Zeitschrift für wissenschaftliche Zoologie* (p. 360, Plate XXVI., Figs. 1 and 2).

The very next year two distinct, extremely simple organisms, very closely resembling Protogenes, were described by the distinguished microscopist Cienkowski. In vol. i. of the *Archiv für mikroskopische Zoologie* (p. 203, Plates XII.–XIV.) he published very interesting "Contributions to the Knowledge of Monads." Among the various Protista here associated by Cienkowski under the old, ambiguous term

"Monads" occur two microscopic inhabitants of fresh water, which in the perfectly simple and structureless constitution of their unnucleated, radiate protoplasmic body resemble Protogenes—the genera Protomonas (*Monas amyli*) and Vampyrella (the latter in three different species); they differ, however, from Protogenes in their mode of propagation. Whereas Protogenes, after it has grown to a certain size, does not gain any further increase of mass, but directly breaks up into two fragments, Protomonas and Vampyrella retract their rays, and pass into the inactive state, and meanwhile the little protoplasmic globule becomes encysted, or surrounded with an envelope (cyst). While so encysted, Protomonas breaks up into a great number of smaller globules, and Vampyrella into four fragments (tetraspores). All of these afterward become free, and by a simple process of growth are developed into the perfect form.

In the mean time I had myself observed, in fresh water at Jena, a fourth allied genus of extremely simple organisms, in all respects like the common Amœba, but distinguished from it by having no cell-nucleus, and no contractile vesicular envelope; hence I named it *Protamœba primitiva.* While in the first-named three slime-globules (Protogenes, Protomonas, and Vampyrella) numerous filaments radiate from the entire surface of the central protoplasmic body, in Protamœba, on the contrary, just as in the common Amœba, there are only a few short, finger-shaped processes, which are constantly changing, being now retracted, and again pushed out in some other place. When Protamœba has, by taking in food—which operation it performs after the manner of Amœba—attained a certain size, it breaks up by division into two parts. I first published my observations of Protamœba in the "Generelle Morphologie," vol. i., p. 133. Afterward I published figures of *Protamœba primitiva*, which are to be found in my "Natural History of Creation," sixth German edition, p. 167, and in my "Anthropogenie," third edition, p. 414.

Backed by these observations, which were still further prosecuted afterward by other investigators, and also by myself, I, in 1866, in the "Generelle Morphologie," established a special class, that of Moneres (i. e., *simple*), for all these organisms of most simple constitution. In the first volume of that work I wrote as follows:

"In order clearly to distinguish from all other organisms made up of heterogeneous parts these simplest and most imperfect of all organisms, wherein neither the microscope nor chemical reagents can detect any differentiation of the homogeneous plasmic body, we give them, once for all, the name of *Moneres*, or simple organisms. Surely, if we would explain life; if we would deduce it from falsely so-called 'dead matter;' if we would fill up the chasm between organisms and the inorganic world—we must needs give special attention to these very interesting but hitherto quite neglected organisms, and lay the greatest stress upon their exceedingly simple morphological constitution, which nevertheless is entirely consistent with the discharge of all the essential functions of life. Inasmuch as in these homogeneous living things no trace is to be discov-

ered of different morphological constituents, of 'organs;' but, on the contrary, as all the molecules of the structureless carbon compound of the living albumen of which they consist are equally capable of performing the various life-functions, it is plain that the idea of an organism can be educed only dynamically or physiologically from vital movement, and not statically or morphologically from the composition of the body out of 'organs.'"

For some years after this the circle of our experiences with these strange "organisms without organs" was considerably widened. During my voyage to the Canary Islands in 1866–'67 I very naturally directed my whole attention to these organisms, and was so fortunate as to discover many new forms of Moneres. On the white calcareous shells of a remarkable Cephalopod (*Spirula Peronii*), found in thousands on the coasts of the Canaries, I have sometimes noticed numerous little red points, which under the magnifying-glass looked like ornamental stars, and, when highly magnified, like orange-red protoplasmic disks or globules, from the circumference of which radiated numerous tree-shaped filaments, with branches. Closer observation showed that these (comparatively colossal) protoplasmic bodies, too, were unnucleated and structureless, and that they propagated after the same manner as Protomonas, the globular, encysted body breaking up into a great number of little fragments. To this new genus of Moneres I gave the name of *Protomyxa aurantiaca*, and it is figured in Plate I. of the "Natural History of Creation." I then, during the same year (1867), found a like magnificent Moneres form in the mud of the harbor of Puerto del Arrecife, the port-town of the island of Lanzarote, and to it gave the name of *Myxastrum radians*. Its distinguishing mark is this, that the fragments or spores into which the globular body breaks up in the act of propagation arrange themselves in lines radiating from the centre of the globule, and exude spindle-shaped, siliceous envelopes, from which the young Moneres afterward drops out.

On the strength of all these observations, I, in 1868, published in the *Jenaische Zeitschrift für Naturwissenschaft* an extended "Monograph of the Moneres" (vol. iv., p. 64, Plates II. and III.). In this monograph both my own observations and those of others are set forth at length and discussed. At that time the number of known genera of Moneres was seven. By later observations it has been increased to sixteen, as is stated by me in my "Supplement to the Monograph of the Moneres" (*Jenaische Zeitschrift für Naturwissenschaft*, 1877, vol. vi., p. 23). The differences between these Moneres come simply from the fact that the soft, slimy mass expands and moves in different forms, and that the asexual propagation (by division, spore-formation, etc.) takes place in different ways.

II. *History of Bathybius.*—The great interest possessed by the Moneres morphologically as well as physiologically was further heightened when, in 1868, the foremost zoölogist of England, the celebrated

Thomas Huxley, described, in the *Journal of Microscopical Science* (vol. viii., new series, p. 1, Plate IV.), a new and quite peculiar species of Moneres, giving it the name of *Bathybius Haeckelii.* Unlike the rest of the Moneres, this Bathybius had included in it certain peculiarly-formed microscopic, calcareous corpuscles—coccospheres and coccoliths; but its formless masses of protoplasm, of very different sizes, were said to cover in enormous quantities the profoundest abysses of the sea, from 5,000 to 25,000 feet depth. With this formless primordial organism of the simplest kind, which, occurring in thousands of millions, covers the sea-bottom with a living layer of slime, a new light seemed to be thrown upon one of the most difficult and most obscure problems of the history of creation—namely, the question of the origin of life upon the earth. With Bathybius, the ill-famed "Urschleim" (primordial slime) appeared to have been found, of which it had been prophetically affirmed, fifty years before, by Oken, that from it was sprung the whole world of organisms, and that this "Urschleim" itself had sprung from inorganic matter at the sea-bottom in the course of planetary development.

The deep-sea ooze containing the masses of Bathybius was first discovered during the deep-sea soundings made in 1857 for the Atlantic cable. The Atlantic Telegraph Plateau, which stretches from Ireland to Newfoundland at a mean depth of 12,000 feet, was found to be covered everywhere with a peculiar gray, very finely-pulverized ooze. This ooze was remarkable for its tough, sticky nature, and under the microscope showed masses of little calcareous-shelled Rhizopods, particularly Globigerinæ, and also, as one of its main constituents, those minute corpuscles known as coccoliths. But it was not till eleven years later, in 1868, that Huxley, with the aid of a very powerful microscope, made a new and thorough investigation of this ooze, calling in also the aid of chemical analysis. He discovered the naked, free, formless protoplasm-masses, which, together with the Globigerinæ and the coccoliths, make up the great bulk of the ooze. "These masses are of different sizes, some being visible to the naked eye, others extremely minute. Subjected to microscopical analysis, they showed, imbedded in a transparent, colorless, structureless matrix, nuclei, coccoliths, and occasionally foreign bodies."

Living Bathybius was first observed in 1868, by Sir Wyville Thomson and Prof. William Carpenter, two practised and sagacious zoölogists, during a deep-sea exploring expedition to the North Atlantic, in the war-ship Porcupine. Of the living deep-sea ooze they write: "This ooze was actually living; it collected in lumps as though albumen had been mixed with it; and under the microscope the sticky mass was seen to be living sarcode" (*Annals and Magazine of Natural History*, 1869, vol. iv., p. 151); and Sir Wyville Thomson, in his very interesting work, "The Depths of the Sea," second edition, 1874, p. 410, adds:

"In this dredging [Globigerina-ooze taken at the depth of 2,435 fathoms in the bay of Biscay], as in most others in the bed of the Atlantic, there was evidence of a considerable quantity of soft gelatinous organic matter, enough to give a slight viscosity to the mud of the surface layer. If the mud be shaken with weak spirits of wine, fine flakes separate like coagulated mucus; and if a little of the mud in which this viscid condition is most marked be placed in a drop of sea-water under the microscope, we can usually see, after a time, an irregular network of matter resembling white-of-egg, distinguishable by its maintaining its outline, and not mixing with the water. This network may be seen gradually altering in form, and entangled granules and foreign bodies change their relative positions. *The gelatinous matter is therefore capable of a certain amount of movement, and there can be no doubt that it manifests the phenomena of a very simple form of life.*"

My own researches on Bathybius-ooze had to do, like those of Huxley, only with dead substance in alcohol. The bottle in which it had been sent to me from the Faroe Islands bore this label: "Dredged of Prof. Thomson and Dr. Carpenter with the steamer Porcupine, in 2,435 fathoms. 22. July 1869.—Latitude 47° 38′, longitude 12° 4′." Thus this Bathybius-ooze was the same on which the observers named above had made their investigations of the amœboid movements. The results of my own investigations I have stated fully in my "Beiträge zur Plastiden-Theorie" (II. "Bathybius and the Free Protoplasm of the Sea-Depths," *Jenaische Zeitschrift für Naturwissenschaft*, 1870, vol. v., p. 499, Plate XVII.). The eighty figures I there give of the different formless protoplasm-masses of Bathybius, and of the little calcareous bodies included in the same, were copied with the utmost exactness from very highly-magnified images of those organisms taken with the aid of the camera lucida. Some of the figures have also been used in my paper on "Life in the Profoundest Depths of the Sea," which was published in 1870, in the Virchow-Holzendorff Collection (No. 110).

This specimen of Bathybius-ooze, which had been very well preserved in strong alcohol, I examined as minutely as possible, employing the newest methods of research, and in particular the excellent method—not employed by Huxley in his investigation—of staining with carmine and iodine, my purpose being, above all, to determine more accurately the quantity and quality of the amorphous protoplasmic matter. This albuminous substance, which was reddened by carmine, was very evenly distributed through the ooze, and in most of the specimens examined constituted at least one-tenth to one-fifth of the whole volume; in many instances it was as much as one-half. The same protoplasmic masses which, on treatment with carmine, became of a more or less deep-red tint, took from iodine and pure nitric acid a yellow color; and with other chemical reagents they exhibited precisely the same properties as the protoplasm of animal and vegetal cells. The form of most of the little masses was irregular, roundish, or provided with obtuse processes resembling those of an Amœba;

others took the form of irregular reticulations of sarcode, like those of the Myxomycetæ.

Whether the little calcareous frustules—coccoliths and coccospheres—which occur so abundantly in Bathybius-ooze, both within and between the protoplasm-masses, actually belong to it or not, I was unable to determine, especially as I had already observed the very same kinds of calcareous frustules in the bodies of sundry pelagic Radiolaria which live at the surface of the ocean off the Canaries ("Myxobrachia of Lanzarote"). These strange calcareous bodies, occurring now in the form of a simple concentrically stratified disk, again resembling a shirt-button, anon assuming the shape of a sphere made up of several disks, and so on,were as likely to be secretions of the Bathybius sarcode as foreign bodies accidentally (or in the process of taking up food) introduced into the protoplasm. Of late the second hypothesis has come to appear the more probable, and biologists now hold that all these corpuscles are microscopic calcareous algæ—calcareate unicellular plants.

These investigations, confirmed as they have been by sundry other observers, seemed to show that at the bottom of the Atlantic, between the depths of 5,000 and 25,000 feet, there exists a sort of ooze which, with its other characteristics, contains a great quantity of a peculiar and as yet hardly individualized species of Moneres. The error into which we now fell consisted in over-hastily generalizing the results of these deep-sea soundings in the North Atlantic, and supposing the bed of the deep sea to be everywhere covered with similar Moneres. This inference was flatly negatived by later research. During the cruise of the Challenger, which extended over three and a half years, though careful search was made for Bathybius in the depths of various seas, it was nowhere found. We have no ground for calling in question the diligence and accuracy of the eminent naturalists attached to the famous Challenger Expedition; and all the less because its director, Sir Wyville Thomson, had been himself the first to observe the movements of the living Bathybius. Hence we must suppose that, in the portions of the deep-sea bottom explored by the Challenger, there were no Bathybius Moneres. But does it hence follow that all previous observations and inferences were incorrect?

As is very usual in such cases, exaggerated and one-sided views were at once given up, and no less exaggerated and one-sided contrary views adopted. Once it was supposed that Bathybius occurred in masses at the bottom of every sea; now its existence anywhere was denied. The Bathybius-ooze preserved in alcohol, which had been the subject of prior investigations, was now held to be nothing but a gypsum precipitate, such as is found wherever sea-water is mixed with spirits of wine. This hypothesis was first put forward by certain naturalists of the Challenger Expedition, and therefore Prof. Huxley recanted—prematurely, as I believe—his earlier views concerning

Bathybius. In *Nature* (August 19, 1875), and in the *Quarterly Journal of Microscopic Science* (1875, vol. xv., p. 392), he writes as follows:

"Prof. Wyville Thomson informs me that the best efforts of the Challenger's staff have failed to discover *Bathybius* in a fresh state, and that it is seriously suspected that the thing to which I gave that name is little more than sulphate of lime, precipitated in a flocculent state from sea-water by the strong alcohol in which the specimens of the deep-sea soundings which I examined were preserved. The strange thing is, that this inorganic precipitate is *scarcely to be distinguished from precipitated albumen*, and it resembles, perhaps, even more closely, the proligerous pellicle on the surface of a putrescent infusion (except in the absence of all moving particles), coloring irregularly, but very fully, with carmine, running into patches with defined edges, and in every way comporting itself like an organic thing. *Prof. Thomson speaks very guardedly, and does not consider the fate of* Bathybius *to be as yet absolutely decided.* But since I am mainly responsible for the mistake, if it be one, of introducing this singular substance into the list of living things, I think I shall err on the right side in attaching even greater weight than he does to the view which he suggests."

These words of Prof. Huxley's awakened marked interest, and were pretty generally thought to be the death-blow of poor Bathybius. But, in proportion as the real parents of Bathybius show a disposition to abandon their child as being beyond hope, the more do I consider it to be my duty as its godfather to defend its rights and, if possible, to restore its expiring vital spark. Here, as luck would have it, I find a valuable ally in the person of a traveled German naturalist, who quite recently observed living Bathybius off the coast of Greenland. The well-known north-polar explorer, Dr. Emil Bessels, who fortunately returned safe after the wreck of the Polaris, writes as follows of the *Haeckelina gigantea*, a giant Rhizopod, probably identical with *Astrorhiza*, previously described by Sandahl:

"During the late American North-Polar Expedition, I found in Smith Sound, at the depth of ninety-two fathoms, great masses of free, undifferentiated, homogeneous protoplasm, without any trace of coccoliths. In view of its truly Spartan simplicity, I gave to this organism (which I was able to study in the living state) the name of Protobathybius. In the report of the expedition it will be figured and described. I would simply say in this place that *these masses consisted of pure protoplasm*, in which calcareous particles occurred only by accident. They appeared to be *very sticky, mesh-like structures, with perfect amœboid movements; they took up particles of carmine, and other foreign substances, and there was active motion of the nuclei.*"—(*Jenaische Zeitschrift für Naturwissenschaft*, vol. ix., p. 277. *See* also Annual Report of the Secretary of the Navy for 1873).

In Packard's "Life-Histories of Animals" is to be seen a figure (published by Bessels) of the protoplasm-net of Protobathybius. From this figure I conclude that Protobathybius is the same as our *Bathybius*.

III. *A Critique of Bathybius.*—Having now presented to the reader the historic facts relating to Bathybius, we next address ourselves to

a *critique* of this subject. We will endeavor, by impartially weighing the facts, to form an unprejudiced judgment on Bathybius, now so decried and so generally discredited.

With respect to *dead Bathybius*—deep-sea ooze brought from the North Atlantic and preserved in spirits of wine—all the observers who have studied it closely agree in saying that it contains greater or smaller masses of coagulated protoplasm, which, in their morphological and chemico-physical properties, bear the closest resemblance to certain Moneres. The results obtained by Huxley from material examined by him—results which I myself have been able to confirm and enlarge—have been admitted as correct by all the other observers who studied the same ooze.

With respect to *living Bathybius,* we have positive testimony as to its characteristic, Rhizopod-like movements from three competent observers, namely, Sir Wyville Thomson, Prof. William Carpenter, and Dr. Emil Bessels. All three made their observations on deep-sea ooze from the North Atlantic. On the other hand, the attempts made by members of the Challenger Expedition in various seas to repeat and confirm these earlier observations on the movement phenomena led only to *negative results.*

What follows now from this testimony, all of which we must recognize as of equal credibility, but which, nevertheless, is self-conflicting? Simply that the Bathybius-ooze *has a limited geographical distribution*, and that it was an over-hasty generalization to people all deep-sea abysses with that organism. But from the fact that the Challenger Expedition did not rediscover living Bathybius it surely does not follow that the observations made *in other localities* by the Porcupine Expedition were faulty. Or, from the fact that the Challenger Expedition found Radiolarian ooze only in a comparatively limited area in the Pacific and nowhere else, must we draw the conclusion that no such thing exists? We know that the vast majority of organic species have a limited distribution; why, then, should not the distribution of Bathybius be limited too?

Hence I confess I cannot understand why Huxley should have so suddenly and so totally changed his views about Bathybius. Still less do I understand how, at the last meeting of the German Naturalists' Association at Hamburg (September, 1876), Bathybius could ever have been publicly interred. In the Berlin *Nationalzeitung* I find the following notable report (dated Hamburg, September 21st) of a paper by Prof. Möbius, on "Marine Fauna and the Challenger Expedition:"

"Over these plateaus [deep-sea plateaus, from 3,700 to 4,000 feet deep] we should look for the mysterious 'primordial slime,' Bathybius, to which the famous Huxley gave the name of *Bathybius Haeckelii* as a compliment to his genial friend of Jena. But, unfortunately, natural history met with a sad mishap. Bathybius, which fitted so nicely into the modern hypotheses of the be-

ginning of things, turned out to be an artificial product of gypsum precipitated by alcohol from sea-water, in which it is held in the state of solution. Wherever fresh specimens of the ooze have been examined on shipboard, no traces of 'Bathybius' have been found. The audience were fairly startled when Prof. Möbius, by simply mixing alcohol with a glass of sea-water, caused Bathybius to appear before their eyes."

Verily, this is a remarkable kind of logic. Because spirits of wine mixed with sea-water precipitates gypsum, therefore Bathybius-ooze kept in spirits of wine is precipitated gypsum! And this demonstration "fairly startled" the members of a German Association of Naturalists! That strong spirits of wine mixed with sea-water produces a light, flocculent gypsum precipitate is known to every one that has preserved marine animals in spirits of wine. But so, too, is it known to every man who, like Huxley and myself, has closely examined the Bathybius-ooze collected by the Porcupine Expedition, that the Moneres-like, albuminous bodies found therein consist actually *of albuminous substance and not of gypsum.* Carmine stains them red, nitric acid and iodine yellow; sulphuric acid decomposes them, and they give all the other reactions of *protoplasm*, which is not the case with gypsum, as every one knows.

If we finely pulverize certain kinds of chalk, or chalky marl, we obtain a fine white flour, that might easily be mistaken for the remarkable Radiolarian ooze found by the Challenger Expedition in a limited area of the Pacific (and there only), at a depths ranging from 12,000 to 26,000 feet. This Radiolarian ooze, which I am at present engaged in studying, consists almost exclusively of the most beautiful and varied forms of siliceous Radiolarian shells. But with the naked eye we cannot distinguish this dried ooze—a wonderful microscopic museum of Radiolaria—from pulverized chalk-marl containing not a single Radiolarian shell. I now propose that at their meeting in Munich next September (1877) the Naturalists' Association experimentally demonstrate that these enormous Radiolarian deposits, discovered by the Challenger Expedition at the bottom of the Pacific, have no real existence. "The experiment is a very simple one." Let the lecturer bray in a mortar, in sight of the assembled naturalists, a bit of chalk-marl containing no Radiolaria. The white powder so obtained does not contain a single Radiolarian; therefore the Pacific ooze (consisting exclusively of Radiolarians) does not exist, since these two substances cannot be distinguished from each other by the naked eye—*quod erat demonstrandum.* We are confident that this striking experiment will "fairly startle" the beholders, and make an end of Radiolarian ooze.

IV. *A Critique of the Moneres.*—From the foregoing, we think it clearly appears that *the non-existence of Bathybius is not proved.* Nay, it is highly probable that the observations of Wyville Thomson and Carpenter and Bessels on the movements of living Bathybius

were correct. We will, however, for the nonce, suppose the contrary to be the fact, and will grant that Bathybius is not a Moneres, nor even an organism. Does it follow from this that the Moneres too have no existence? Or must we say that, as the familiar great sea-serpent of fable does not exist, therefore there is no such thing as a sea-serpent? We know that there are many sea-serpents belonging to the family of the viviparous and highly-venomous *Hydrophidæ* (*Hydrophis*, *Platurus*, *Æpysurus*, etc.), which chiefly inhabits the Indian Ocean and the Sunda Archipelago, but none of which attain any considerable size.

It were useless here again to quote my own researches which have demonstrated the existence of upward of a dozen different species of Moneres, some living in fresh, others in salt water. I would, however, state that these observations have since been repeated and confirmed by a number of competent investigators. Some of these Moneres appear to be very widely distributed in fresh water, as for instance the genera Protamœba and Vampyrella. *Protamœba agilis* and *Vampyrella spirogyræ* may be observed almost any summer at Jena. *P. primitiva* and *V. vorax* have been seen by sundry observers in very diverse localities. Other new Moneres forms have been quite recently discovered by Cienkowski and Oskar Grimm. When the attention of microscopists has been more generally directed to these extremely simple organisms, we may hope that our knowledge of them will be considerably widened and deepened.

Whether Bathybius is or is not a true Moneres, at all events we already know with certitude a number of *true Moneres* whose fundamental importance is quite independent of Bathybius. We know that even now there exist in the waters of our planet a number of very low forms of life, which are not only the simplest of all actually observed organisms, but even the *simplest imaginable* of living things. Their whole body, in the fully-developed and reproductive condition, consists of nothing but a little mass of structureless protoplasm, whose changing, variable processes all at once discharge the various life-functions—movement, sensation, transmutation of matter, nutrition, growth, and reproduction. Morphologically considered, the body of a Moneres is as simple as an inorganic crystal. We cannot distinguish in it separate parts; or, rather, each part is equivalent to each other. These facts and their far-reaching consequences apply to *all Moneres* without exception—with or without Bathybius!—and hence it does not affect the theory at all whether Bathybius exists or not.

When we describe these Moneres as "absolutely simple organisms," we of course only express their *morphological simplicity*, the absence of distinct organs. Chemico-physically, they may be highly composite; indeed, we must in any case ascribe to them, as to all albuminous bodies, *a highly-complex molecular structure.* Many regard the slime-like albuminous body of Moneres as a single chemical albu-

men combination, while others see in it a multitude of such combinations; others, again, regard it as an emulsion or intimate blending of albuminous and fatty particles. For a general biological view of the Moneres this is of subordinate interest; for, however the case may be, the creature is at all events, *from the anatomical point of view*, perfectly simple—an organism without organs. It proves incontrovertibly that life does not depend on the coöperation of different organs, but on a certain chemico-physical constitution of amorphous matter—on that albuminous substance which we call sarcode or protoplasm—a nitro-carbon compound in the semi-fluid state.

Hence, life is not a result of organization, but *vice versa*. Amorphous protoplasm gives rise to organized forms. Having already, in previous writings, called attention to the high importance of the Moneres from this and other points of view, I can here only refer to those papers. At present I must content myself with pointing out the importance of the Moneres in connection with the great question of the origin of life. The oldest organisms, sprung by spontaneous generation (Urzeugung) from inorganic matter, must have been Moneres.

It is precisely the general importance of the Moneres for the solution of the greatest of biological problems that makes them a stumbling-block and a scandal to the opponents of the doctrine of evolution. These men, of course, take every opportunity to dispute the existence of Moneres, exactly as was done in the case of *Eozoön Canadense*, the much-disputed oldest fossil of the Laurentian formation. The most experienced and competent students of the class Rhizopoda—at their head Prof. Carpenter, of London, and the distinguished anatomist Max Schultze, of Bonn, deceased—are firmly convinced that the American Eozoön is a genuine Rhizopod—a Polythalamium, near akin to Polytrema. I have myself for several years made a special study of Rhizopods. I have minutely examined several fine preparations of Eozoön made by Carpenter and Schultze, and I have not the slightest doubt that it is a genuine Polythalamium, and not a mineral.

But, just because of the extraordinary fundamental importance of Eozoön, and because the discovery of that fossil adds several millions of years to the earth's organic history, making the primitive Silurian formations to appear recent by comparison, and rendering a great service to the doctrine of evolution, therefore it is that the opponents of that doctrine so stoutly affirm that it is not of organic origin at all, but purely mineral. But as the high importance of Eozoön was placed in its proper light by these unavailing attacks of ill-informed opponents, so is it, too, with the Moneres—with or without Bathybius. The true Moneres remain, forming an immovable foundation-stone of the doctrine of evolution.—*Kosmos.*

MOLECULAR MAGNITUDES.

By L. R. CURTISS.

IN entering upon an analysis of the subject of atomic and molecular magnitudes, it is desirable that we should have as clear an idea of the immeasurably small in Nature as possible. To the astronomer the size and relative distances of the celestial bodies are real magnitudes, and so also, to the molecular physicist, the magnitudes verging upon the infinitely small are just as much of a reality. The billionth part of an inch is just as much of a fact as a billion miles.

The mathematical definition of a point consists in stating it as a locality without length, breadth, or thickness; but we receive no very concise idea of the definition until we proceed graphically, and make a dot with a pencil or otherwise, which shall possess limited dimensions of length and breadth; then, by the metaphysical process of abstraction, we dispense with the linear dimensions of length and breadth, and thus purify our conceptions concerning physical magnitudes, and place ourselves in a way of realizing the entity or real existence of the invisibly small in Nature.

In the animal kingdom are found myriads of forms so minute that their bulk is reckoned by less than the millionth part of a cubic inch, yet each one is endowed with organs of sense or assimilation sufficient to serve the purpose in their sphere of life. The vegetable kingdom, also, offers abundant specimens of microscopic forms, calculated to excite our admiration by the beauty and minuteness of their organisms. Such is notably the case in several forms of *Diatomaceæ*. The striated markings of *Pleurosigma fasciola* aggregate to 64,000 to the inch, while *Amphipleura pellucida* often exhibit striæ exceeding 100,000 to the lineal inch. And yet the skeletons of these minute organisms are composed mainly of silex, the silex again being made up of silicon and oxygen. Notwithstanding the almost infinitesimal magnitudes of the organic world, human skill is able to compete in the matter of minuteness. Platinum wire has been drawn so fine as to rival in minuteness the smallest fibre of the spider's web. Gold has been deposited upon the surface of other metals, and drawn to such extreme thinness that a thousand-millionth part of a grain exhibited the visible characteristics of the metal. The oscillations of the horizontal pendulum can be measured to the $\frac{1}{800000000}$ part of an inch, by the aid of a small mirror, a beam of light, and a graduated scale for reading the vibrations. Nobert, with a mechanical skill unsurpassed, has repeatedly ruled with a diamond-point upon glass the nineteenth band of his test-plate, consisting of lines less than the $\frac{1}{112000}$ of an inch apart, and it is claimed that he has succeeded in

ruling plates covering 224,000 lines per inch, such as would aggregate in superficial areas to over 50,000,000,000 to the square inch! Such minute divisions are wholly beyond the resolving power of the most elaborate of modern microscopic appliances; for it has been shown by Sorby [1] that the ultimate power of the microscope for distinct definition is limited to the examination of magnitudes not less than one-half of the average wave-length of the luminous spectrum; and it is shown, upon the authority of Helmholtz, that when the amplitude of the object is less than this half wave-length—or somewhat in excess of 80,000 to the inch—the dark interference-fringes impair the definition of the instrument, except in the case of striated markings, which may be clearly defined, or resolved, by so arranging the illumination as to mask the fringes, and bring out a good definition even in excess of 100,000 to the inch. Hence, the main difficulty attending the possible amplification of objects less than about the $\frac{1}{100000}$ of an inch in diameter is a purely physical one, and depends upon the constitution of light itself.

The various phenomena of chemical physics teach us that matter is not homogeneous, but is made up of infinitesimal particles or atoms, the term *atom* meaning *indivisible particle;* and that the term *molecule*—meaning literally *a little mass*—refers to an aggregation of two or more atoms. Thus, a crystal of common salt may be pulverized until one of its fragments is barely discernible to the highest range of microscopic power, and still this fragment will retain all the characteristics of salt. This same microscopic portion is susceptible of a further subdivision by solution in water, when the spectroscope will detect its presence in the still minuter quantity of the one-hundred-millionth part of a grain. Here, in the case of salt, physical analysis ends, and, aside from chemical analysis, any further subdivision must be by the process of abstraction, until by its means we arrive at the mental conception of a portion so minute as to consist of an atom of sodium united by the bonds of chemical affinity to an atom of chlorine. This is now a molecule of common salt. Any further division destroys the entity of the compound, and results in the decomposition of the salt into the atoms of its elements. Hence a simple molecule is the smallest portion of any chemical compound that is not susceptible of subdivision without destroying its entity, or, in other words, the smallest number of atoms that can cohere to form a compound constitute the molecule of that compound. An atom is designated as the ultimate particle of any elementary body, and is not susceptible of any further division within the range of human analysis.

Were it possible to magnify the atoms of matter to a diameter available for distinct vision, we should be met at the outset by a difficulty too astounding for realization. It is a matter of easy proof

[1] H. C. Sorby, F. R. S., in his anniversary address to the Royal Microscopical Society, in the *Quarterly Journal of Microscopical Science* for April, 1876.

that the magnifying of any object while in motion will exhibit that motion increased in velocity just as many times as the diameter of the object is augmented. Suppose we had at our command an instrument competent to amplify the atoms to the one-fiftieth of an inch in diameter: in the case of the hydrogen-atom the necessary magnifying power would be 10,000,000 diameters, under which power the atoms would have their motions enhanced by the same multiple, and we should then be called upon to examine an image the fiftieth part of an inch in diameter plunging across the field of vision five hundred million times faster than the flight of a cannon-ball.

It follows, since human skill is incompetent to penetrate by any mechanical means into the internal structure of matter, that we shall be compelled to direct our labors to other modes of investigation if we would know more of the atomic structure of matter, possessing as it does a minuteness far surpassing the analytical power of the microscope; in fact, so hopelessly ultra-microscopic as to elude all other processes except that of mathematics and experimental investigation.

The question of the infinitely large and the immeasurably small has engaged the attention of philosophers since the days of Democritus. Modern investigators are, however, in possession of experimental data that aid them in arriving at facts with ever-increasing accuracy. We have the atomic theory first placed upon a substantial basis by Dalton, which treats of the atomic constituents of matter, and gives to each atom a definite size and weight, and establishes the proposition that atoms combine to form molecules, and that molecules aggregate to masses. We have also the kinetic theory of gases, which has been placed upon a purely mathematico-scientific footing, as has also the department of hydro-kinetics; and experiments within these departments are accumulating evidence concerning the atomic and physical structure of matter.

The kinetic theories are based upon the conception that these particles or atoms are in constant motion among themselves; and it assumes, also, that their movements have an infinite series of velocities in all conceivable directions, but with varying degrees of intensity. This idea of atomic and molecular motion puts us in possession of an important factor for determining the causation of all physical phenomena. Of course we do not presume to say that the atom is the primordial or ultimate constituent of matter, for there are many evidences to show that the present list of sixty-five elements of matter may not be elementary at all, but isomeric compounds of one or more simpler constituents.

The question might here be asked, "How does the physicist know anything of the relative size of atoms and their vibratory motions?" The answer is: by mathematical deductions, based upon the behavior of gases; by experimental evidence, principally in the domain of radiant heat; also in the interdiffusion of liquids and gases. Researches

in these departments have determined, with a great deal of certainty, that the atoms and molecules of matter do not touch each other, and that the various velocities they may assume under different conditions are the causes of all the phenomena of light and heat. And, moreover, it has been determined by the most refined experiments, with special instruments of precision, that these atoms have a definite size and weight, and, under special conditions, a definite velocity and momentum. The pressure of gases has also been defined as the resultant of the molecular bombardment or impact of these flying projectiles against the sides of the containing vessel.

Some molecular data have been tabulated from the calculations of Clausius, Maxwell, Thomson, and others, but the figures given are wholly beyond human comprehension. Thus the number of atoms in one cubic inch of hydrogen-gas, at the temperature of freezing water and under the pressure of one atmosphere, is given in the neighborhood of three hundred millions of millions of millions, each atom possessing an initial velocity of over a mile per second, covering nearly eighteen billions of oscillations in different directions in the same second of time. That is to say, each particle of hydrogen, while moving at the rate of seventy miles per minute, has its course wholly changed something like 17,700,000,000 times in every second. Sir William Thomson concludes, from the data given by Clausius, that the diameter of the gaseous molecule is somewhere between the $\frac{1}{250000000}$ and the $\frac{1}{500000000}$ of an inch, and as the density of known liquids and solids is from 500 to 16,000 times that of common air, he concludes that the distance from centre to centre of contiguous molecules in solids is less than the $\frac{1}{2500000000}$ and greater than the $\frac{1}{5000000000}$ of an inch; and he illustrates by supposing "a drop of water to be magnified up to the size of the earth, each molecule to be amplified in the same proportion, these molecules will then be less in size than cricket-balls, but larger than small lead-shot."

Imagine the particles of the air we breathe flying about at the rate of eighteen miles per minute—a velocity exceeding that of a cannon-ball—a velocity which, if the particles were all moving in one direction, would constitute a tornado ten times more violent than any terrestrial hurricane! How is it, then, that we can survive the incessant bombardment of such a storm of projectiles? Simply because the particles are moving in all directions, so as nearly to counterbalance each other's momentum. Were it not that the molecules are continually changing their direction by executing a sort of carrom upon their neighbors, the interdiffusion of liquids and gases would be almost instantaneous. If the molecules could project in straight lines without interference with each other, the opening of a bottle of perfumery would permit the diffusion of its odor to the distance of many hundred feet sooner than you could open and recork the bottle, or, in some instances, about one-third of a mile in one second of time.

An instructive experiment may be made: First, finely pulverize indigo, charcoal, or carmine, and then mix either of them with water, and place under the microscope, when an incessant movement of the small granular particles will become apparent; and the smaller the particles, the more rapid and uniform will be their movements. These movements are chiefly of a vibratory kind; and it is when the particles are minutely divided, so as to approach the limits of microscopic range, that this vibratory motion, together with an irregular axial rotation, approaches a degree of perfection that is beautiful as well as suggestive. This experiment is well calculated to assist us in forming a mental conception of the magnitudes and the motions of those atoms and molecules which have for their realm the regions below and beyond the immeasurably small.

As to the shape and internal structure of atoms, there is no definite knowledge; but Helmholtz's studies of certain equations in hydro-kinetics, several years ago, gave rise to the idea that vortex-motion in a frictionless medium would exist forever—an assumption which is purely hypothetical; but since the proposition has been enlarged upon by Sir William Thomson—who conjectures that the atoms might be filaments or rings endowed with a vortex-motion—the subject assumes a shape better calculated to form the basis of a scientific theory. To be sure, mathematical formulas might show that the behavior of a vortex-filament in a non-resisting medium would answer to that ascribed to atoms—indestructible and unalterable through all time; still, at the same time, the means at hand for its complete mathematical verification are not adequate to place the subject beyond the regions of theory. Prof. Tait, in a review of this subject in his "Recent Advances of the Physical Sciences," remarks that, "with a little further development, it may be said to have passed its first trial, and, being admitted as a possibility, may be left to time and the mathematicians to settle whether it will really account for everything experimentally found."

Small as these atoms are, we are not permitted to stop here, but remember that there is a finer medium environing them all, embracing possibly a complexity of internal structure sufficient to baffle human investigation for all time. This cosmic or luminiferous ether is supposed to fill all space, intermolecular and interstellar, and to be the medium in which the atoms and molecules move like motes in the sunbeam.

Atoms and molecules may vibrate to and fro, or may execute various oscillations about each other, with a moderate velocity, or perform their motions with a rapidity beyond conception; and be the intensity of the vibrations ever so great or ever so small, these same vibrations determine the amplitude of the ethereal waves—those waves of greatest length giving rise to all the phenomena of radiant heat, while shorter ones constitute light in all its luminous and chromatic effects; as also

the ethereal waves of still more rapid undulations and lesser length furnish the actinic force of light. And if the mathematical deductions of such as Maxwell and Boltzmann, together with the refined researches of many others in this border-land of science, are not at fault, we would not be surprised if, at some early day, the solution of the phenomena of electricity should be found in some way connected with ethereal vibrations, infinitely more rapid and minute than those which produce the actinism of the ultra-violet spectrum. The difficulties attending the solution of this problem may be more fully comprehended when we recollect that, in dealing with vibrations more rapid than those bordering the visible spectrum, we are leaving regions where the undulations comprise nearly one thousand million of millions in a second of time, only to be confronted with others of infinitely greater rapidity.

These ethereal and molecular actions are going on eternally about us. The photographer's sensitized plate may receive an image that maps out the constellations, or, through the prism of the spectroscope in lines of light, we may read of the constituents of the nebulæ, and thus upon the waves of ether do we hold communion across the universe by that ethereal chain of motion which binds us to the stars!

SIMPLE EXPERIMENTS IN OPTICS.

By ELIZA A. YOUMANS.

THE little work of Mayer and Barnard, designed to introduce beginners to the experimental study of optics, is so much needed, so skillfully done, and may be so helpful to teachers and students of all ages, that it is desirable to offer a few illustrations of the method of experiment adopted, and to point out some of the cheap and simple ways which Prof. Mayer has hit upon for exemplifying and proving optical phenomena. We shall make free use of his text as well as his cuts in the present article. Fig. 1, for example, represents the arrangement adopted to prove that light moves in straight lines. He first gets three little blocks, two or three inches square; then three slips of pine, three inches by four and one-eighth of an inch thick; and then three postal-cards, through which a small aperture is to be made. The authors say: "Just here we need a tool for making small holes and doing other work in these experiments; and we push, with a pair of pliers, a cambric needle into the end of a wooden pen-holder or other slender stick, putting the eye-end into the wood, and thus making a needle-pointed awl." This is an excellent little contrivance, and we suggest to the pupil to make a set of them with different-sized needles, which he will find very useful. Now, lay the postal-

cards flat on a board, one over the other; measure off a half-inch from one end of the top postal-card, and with the awl punch a hole through them all just half-way from each side. Trim the holes with a pen-knife, and then take one of the cards and one of the wooden slips and put the card squarely on one of the wooden blocks, and, placing the slip over it, tack them both down to the block. Place one of the blocks near a lighted lamp, as shown in the figure, and another at the

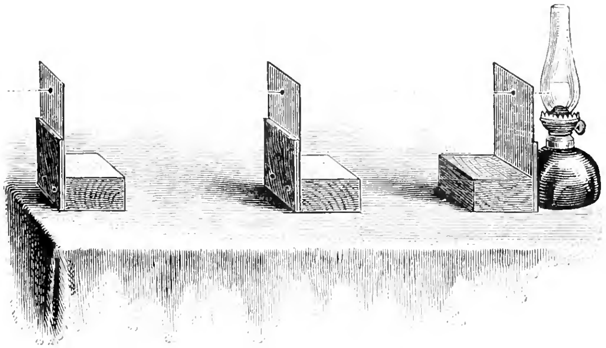

FIG. 1.—EXPERIMENT PROVING THAT LIGHT MOVES IN STRAIGHT LINES.

opposite side of the table, where the observer can sit to look through the aperture. When the light is seen through both openings, draw the third card into line between the others, when the ray will be seen to pass through all three cards. Next, take a piece of thread and stretch it against the sides of the three cards as they stand, and it will be seen that they are exactly in line, and, as the holes in the cards are at the same distance from their edges, it is proved that the beam of light that passes through all the holes must also be straight. If the position of the blocks is changed, so that the directions of the holes in the cards are different, the same effect will be observed, so that it is demonstrated that light moves in exactly straight lines in all directions from the source of illumination. Of course, a pupil can learn from a book that light moves in straight lines, but this will be a matter of hearsay or authority, and not of direct knowledge, while if he makes this experiment he will have begun to prove things for himself, and the preparation for it, and trial in different ways, will be a good exercise in manipulation.

Now, if the student wishes to prove the variation in the quantity or intensity of light at varying distances, he can do it in the simple way shown in Fig. 2. A small slit is cut in the card near the lamp, through which the light passes. A sheet of white paper, resting against some books at the opposite side of the table, forms a screen, upon which the light falls. A bit of paper, an inch square, is held by the point of the awl, the handle of which is stuck in some

wax on the table. Set the needle-awl, with the bit of paper, about twelve inches from the lamp, and then darken the room. Upon the screen, which is placed two feet from the lamp, will then be seen the shadow of the square bit of paper. With a lead-pencil trace an outline of this shadow on the screen, and then move it a foot farther back; and note how much the shadow is increased in size. With the pencil trace this shadow on the screen, and then laying the paper

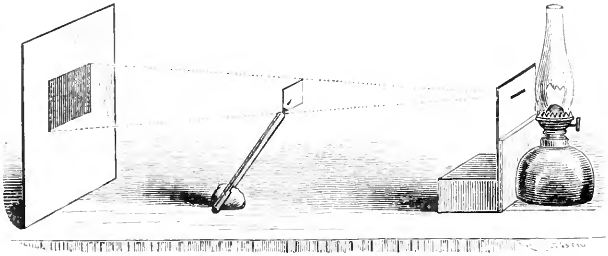

FIG. 2.—EXPERIMENT WITH SHADOWS.

on the table and measuring the two shadows, you will see how they compare in size, and get a clew to the principle of inverse squares, as it is called.

Fig. 3 represents the means used in showing that the angle of the ray as it strikes the mirror is the same as that at which it is reflected. *A* and *B* are two of the postal-cards and their blocks used in the first experiment, turned with their inside faces toward each other, and separated by three more blocks of the same dimensions as those sup-

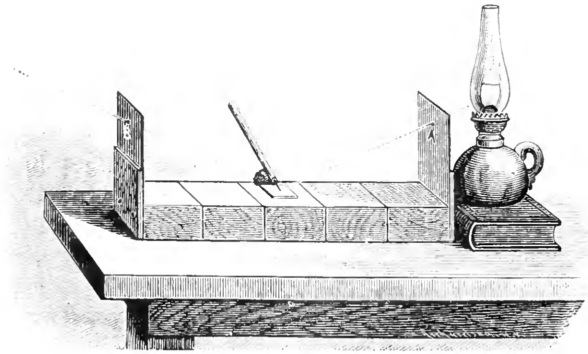

FIG. 3.—ANGLE OF INCIDENCE AND REFLECTION.

porting the cards. The flame is placed even with the hole. On the middle block rests a piece of glass, coated on the bottom side with black varnish. The eye looks through the hole *B* upon the glass, where it sees a small spot of light that is the reflection of the ray from the lamp through the hole *A*. The point of the needle is placed

directly over this spot, and held in position by the wooden handle with a piece of wax. A strip of paper, filling the distance from *A* to *B*, and four inches wide, is held upright between the cards, with the bottom resting on the mirror. The edge of this is marked with a pencil at the hole *A*, and again at the needle-point. A straight line joining these marks will form an angle at the bottom of the paper that is identical with the angle of incidence. By reversing the ends of the paper, and comparing this line with one from *B* to the needle, both will be found alike. The angles of incidence and reflection agree.

In regard to the reflection of light, Prof. Mayer remarks:

"The clouds, the water, the grass, rocks, the ground, buildings, the walls inside, clothing and furniture, and everything we can see, reflect light in every direction again and again, and thus it is that all spaces, without and within, are filled with light so long as the sun shines. At night the sun sinks out of sight, and still it is light for some time after, for the sunlight is reflected from the sunset-clouds and the sky. Sometimes, upon a summer's day, when broken clouds partly hide the sun, you will see long bars of dusky light streaming from openings in the clouds. These long bars are beams of sunlight shining upon dust and fine mist floating in the air, and we see them because each speck and particle reflects light in every direction."

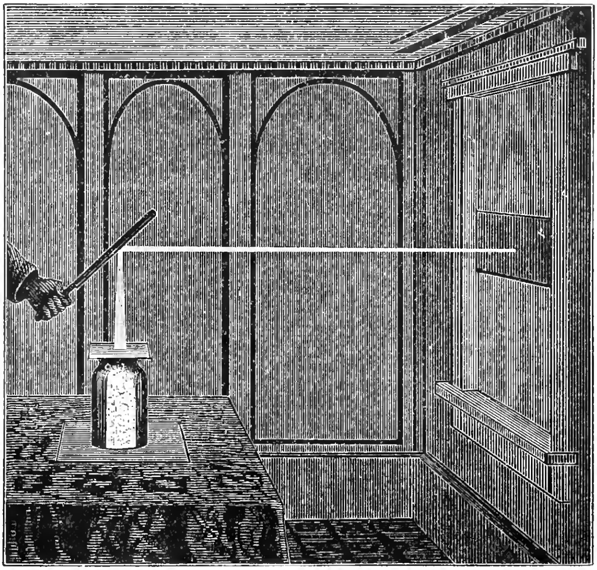

Fig. 4.—Light reflected by Floating Particles.

Fig. 4 shows the effect of particles in scattering the light. A clean glass jar stands upon a black cloth laid on a table in a dark room, and over its mouth rests a postal-card having a slit in it one inch long and one twenty-fifth of an inch wide. A beam of light enters the room from one side, and is thrown downward upon the postal-card by a

hand-mirror. Now set fire to a small bit of paper, and drop it into the jar. When it is burned out, put the postal-card in place, and the vessel will be filled with smoke. The beam that is reflected downward from the mirror enters the slit, and you see a slender ribbon of light extending downward through the jar, while all around it is quite dark and black. Fig. 4 shows the light streaming through the opening in the card, and lighting up the particles of smoke in its path. Take off the card, and let the reflected beam fall freely into the jar: the smoke is now wholly illuminated, and the vessel appears to be full of light

To make a milk-and-water lamp:

> "Take away the jar and put a clean glass tumbler in its place. Fill this with water and throw the beam of reflected light down upon it, and the water will be lighted up so that we can easily see the tumbler in the dark. Now add a teaspoonful of milk to the water and stir them together. Throw the beam of light down once more. This is indeed remarkable. The tumbler of milk-and-water shines like a lamp, and lights up the room so that we can easily see to read by its strange white light. Move the mirror and turn aside the beam of light, and instantly the room becomes dark. Turn the light back again, and once more the glass is full of light. Here the minute particles of milk floating in the water catch and reflect the light in every direction, so that the entire goblet seems filled with it, and the room is lighted up by the strange reflections that shine through the glass."

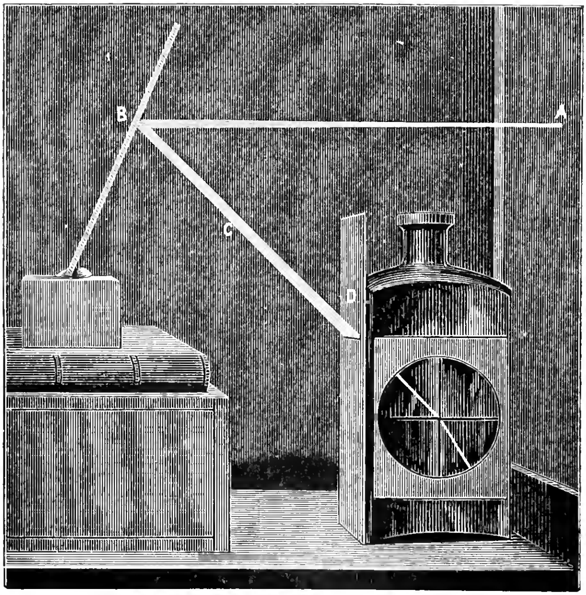

FIG. 5.—EXPERIMENT SHOWING THE LAW OF REFRACTION.

By the following simple contrivance, illustrated in Fig. 5, Dr. Mayer shows the pupil how he can demonstrate the law of the refraction of

light: 1. We have a clear glass bottle, with a sheet of white paper, in which a perfectly round hole has been cut, pasted on its side; 2. Horizontal and perpendicular lines are drawn with ink upon the glass at right angles across each other, and within this circle, dividing it into four equal parts; 3. Water is poured into the bottle until its level is that of the horizontal line; 4. A postal-card containing a slit is placed as at *D* in the figure; 5. The mirror, *B*, reflects the beam into the bottle so that it may touch the water where the two lines cross. The light is seen to bend as soon as it enters the water. The index of refraction for all liquids may be determined by measuring the distance from where the beam enters to the perpendicular, then the distance from the perpendicular to where it vanishes, and dividing these into each other. The constancy of the quotient for each particular liquid can also be shown by having the beam strike the water at various angles, making these measurements and dividing. No matter how the distances vary from the perpendicular, when divided into each other they give the same result for the same liquid.

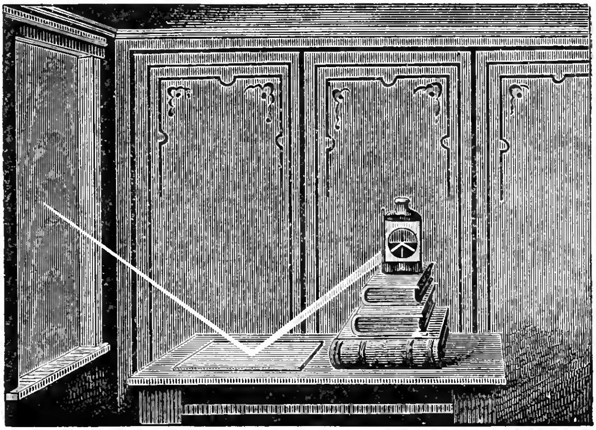

FIG. 6.—TOTAL REFLECTION.

With a mirror on the table and our bottle arranged as in Fig. 6, total reflection will occur, that is, all the light of the beam will be thrown downward from the surface of the water.

"Sometimes, when walking along a road on a warm day, you may observe a curious quivering in the air just where the road seems to meet the sky, as it goes over a hill. The objects near this point appear to be distorted and to tremble, or they assume fantastic shapes. Here we have an instance of refraction caused by the heated air just above the surface of the road. The light passing through these layers of unequally-heated air is refracted unequally, and the objects that reflect the light appear distorted. In some instances the refraction may pass the critical angle, and we may see the objects apparently doubled by reflection. Warm, calm days by the sea show the same thing, when distant

vessels appear repeated in the sky, or when distant land that is really below the horizon 'looms' up and glimmers upon the horizon in trembling headlands. This illusion is called the mirage, and takes place when refraction exceeds the critical angle and becomes reflection.

"Fill a clear glass tumbler with water, and put a spoon in it, or dip one finger in the water, and hold it above your head, so that you can look into the water from below. You will find that you cannot see through the water up into the air above. The under-surface of the water will appear to shine like burnished silver, and the spoon or your finger will be reflected in it, as in a beautiful mirror. This illustrates total reflection, and shows that in this case all light thrown upward through the water is reflected from its surface. Look into the tumbler from above, and it appears full of clear water. Look into it from below, and it seems as if an opaque sheet of silver rested on the water, and shut out the view of everything above."

Fig. 7 shows a neat and simple arrangement by which water can be used for a lens to illustrate refraction. It is merely a long pine box fourteen inches high, made of thin boards, with one side open, and a round hole in the top five inches in diameter. On this opening rests a hemispherical glass dish made by cutting off the round top of a glass shade, and which is filled with clear water. A piece of looking-glass is supported below at an angle of forty-five degrees, so as to reflect a stream of sunlight upward through the water-lens. The rays are thus refracted and brought to a point at a proper distance above. If a sheet of paper is held horizontally just over the bowl, it will be lighted up by the rays coming through the lens. Raise the paper slowly, and the circle of light on its surface will grow smaller and brighter, till it is reduced to a point, when it will burn a hole in the paper. If a little smoke is diffused through the space, it will reveal the double cone of light, with one base upon the surface of the water-lens, and the other forming a large circle of light upon the ceiling, the rays all crossing at the focal point. With some additional attachments Prof. Mayer makes such a lens work in a magic lantern for projecting large pictures upon screens, the whole mechanism being estimated to cost but $3.20.

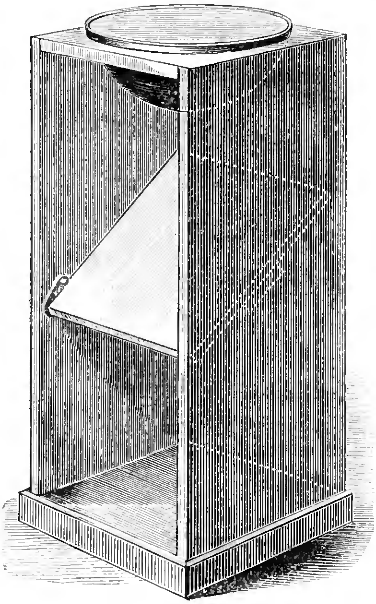

Fig. 7.—The Water-Lens.

One of the most beautiful experiments in total reflection is that illustrated by Fig. 8. A Florence flask filled with water acts as a

lens. The room is darkened, and the light coming from without is brought to a focus on the inside of the flask. A hole has been made through the glass, and as the water streams out the light is totally

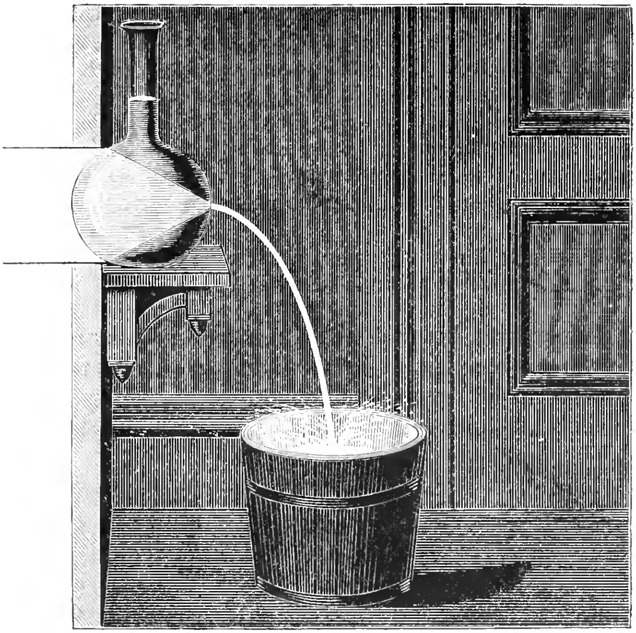

FIG. 8.—THE FOUNTAIN OF FIRE.

reflected so as to illuminate the stream as it falls into the pail below. Of this experiment the authors say:

"How magical! The curving stream of water is full of light, and appears like a stream of molten iron. The spot where it falls seems touched with fire. Put your finger in the stream of water, and it is brightly illuminated. Of course, the water soon runs down, and the display stops. To prevent this, bring water in a rubber tube from the water-pipes in the house, and then regulate the supply so that the receiver may be kept full as fast as the water runs out.

"Place a piece of red glass behind the flask in the beam of sunlight, and the stream of water will look like blood. Touch it, and the hand will be crimson, and the scattered drops that fall in a shower into the tub will shine like drops of red fire. Place a green or blue glass behind the flask, and the stream of water will turn green or blue, and present a most singular appearance. Hold a goblet in the stream, and it will overflow with liquid light. Flashes and sparkles of fire will appear in it, and foam over the sides, shining with brilliant light.

"This beautiful experiment is as interesting as it is strange and magical, and it illustrates both refraction and total reflection. The flask makes a lens, and the falling stream of water is lighted up by the cone of light that enters it at the hole in the flask. Both the water and the light pass out of the hole together,

the light inside of the water. That this is so, may be proved by permitting the water to escape, when the light will be seen shining out of the hole horizontally into the room. Why, then, does it not shine out into the room while the water is escaping? When the stream of water is flowing out, it falls in a curve into the tub on the floor. The beam of light, passing out with the water, meets its curved surface at such an angle that it is totally reflected. This beam of reflection again meets the surface of the water, and is again totally reflected. In this manner it is reflected from side to side, again and again, till it reaches the tub, and there we see it shining brightly. It is a prisoner in the water, and follows it down into the tub. When you put your hand in the falling water, you see that it is lighted brightly, and yet the stream by comparison is rather dark. If it were pure distilled water it would hardly be visible. As it is full of floating specks and motes, each of these reflects light, and these cause the water to appear full of light.

"This fountain of fire is a charming experiment for a school, and its double lesson makes it as interesting as it is beautiful."

Prof. Mayer uses his flask-and-water lens, as illustrated in Fig. 9, to get a solar microscope, and so well does it succeed that it is doubtful if it can ever be excelled for combined cheapness and efficiency. With some blocks of wood, a twenty-five-cent microscopic glass lens,

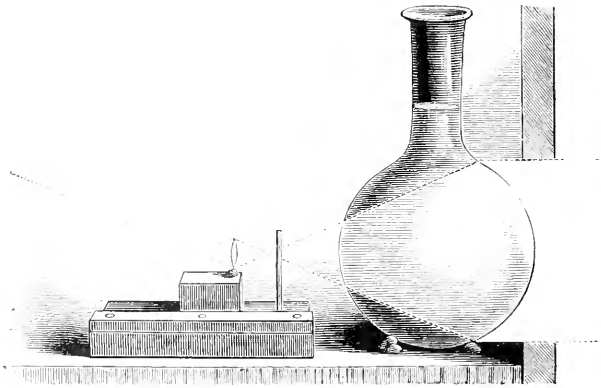

Fig. 9.—The Solar Microscope.

and a slide carrying a microscopic object, he gets very striking effects. Animalcules in water, and all sorts of transparent microscopic objects, can be projected upon a curtain by its aid, so that a large number of people can be entertained by observing the effects produced.

Fig. 10 shows how a common iron top, such as may be found in any toy-store, may be transmuted into a color-top. The shape of the handle is of no importance. By fastening disks of various colors, made of drawing-paper, around it, all sorts of chromatic changes may be studied. With red, green, and violet, white will appear by spinning the top. With one-quarter green and three-quarters red a deep

orange may be produced. Directions are given for using the top on the lantern, and casting the colors on the screen, so that a great many persons may see it at once.

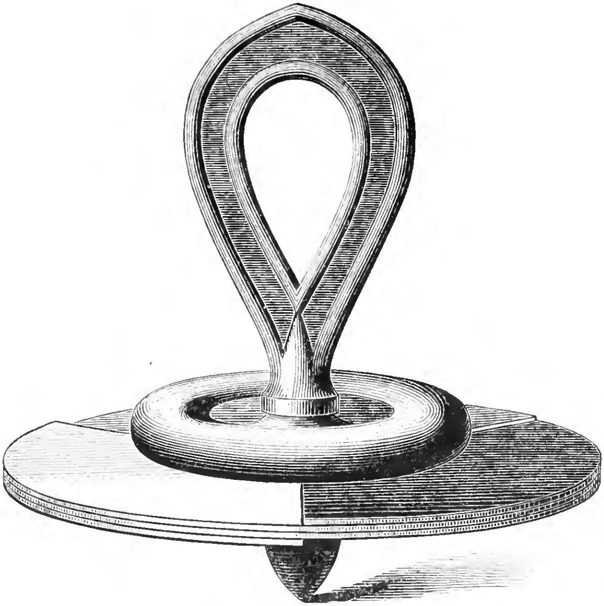

FIG. 10.—THE COLOR-TOP.

Another method of producing these recompositions is illustrated in Fig. 11. We have here a square piece of board for a base, an upright block at the corner, two pieces of glass to which the dotted lines

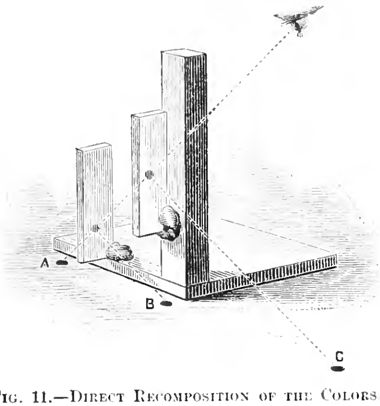

FIG. 11.—DIRECT RECOMPOSITION OF THE COLORS

run, and in which reflections are to be seen at the spots where the lines meet, and three pieces of paper at *A*, *B*, and *C*, painted respectively red, green, and violet. The image of *A* is supposed to go through

both pieces of glass to the eye, while the reflected images of *B* and *C* are, by adjustment, to be made to overlap each other and the image of *A*. When this is accomplished a single white object is seen. This experiment is conducted most successfully near a window, and with the back toward the light. When the red and green images are superimposed a yellow one is seen, and when the green and violet are superimposed we have blue. The colors originally supposed to be primary were red, yellow, and blue. Prof. Mayer has here given a simple means of refuting this old theory.

Prof. Mayer describes the construction of a cheap and simple heliostat for directing the sunlight into the room, and keeping the beam in the same position for all these experiments. We refer the reader to the book for the details of its construction, and the full-page woodcuts by which it is illustrated. A great point has been gained for scientific education by thus putting it in the power of any student, with ordinary ingenuity, a few tools, and a few shillings, to make such a large number of interesting and instructive experiments.

ON ELEMENTARY INSTRUCTION IN PHYSIOLOGY.

By T. H. HUXLEY, F. R. S.

THE chief ground upon which I venture to recommend that the teaching of elementary physiology should form an essential part of any organized course of instruction in matters pertaining to domestic economy, is that a knowledge of even the elements of this subject supplies those conceptions of the constitution and mode of action of the living body, and of the nature of health and disease, which prepare the mind to receive instruction from sanitary science.

It is, I think, eminently desirable that the hygienist and the physician should find something in the public mind to which they can appeal; some little stock of universally-acknowledged truths, which may serve as a foundation for their warnings, and predispose toward an intelligent obedience to their recommendations.

Listening to ordinary talk about health, disease, and death, one is often led to entertain a doubt whether the speakers believe that the course of natural causation runs as smoothly in the human body as elsewhere. Indications are too often obvious of a strong, though perhaps an unavowed and half-unconscious, undercurrent of opinion that the phenomena of life are not only widely different, in their superficial characters and in their practical importance, from other natural events; but that they do not follow in that definite order which char-

[1] A paper read at the Domestic Economy Congress, held in Birmingham, England, July 17–19, 1877.

acterizes the succession of all other occurrences, and the statement of which we call a law of Nature.

Hence, I think, arises the want of heartiness of belief in the value of knowledge respecting the laws of health and disease, and of the foresight and care to which knowledge is the essential preliminary, which is so often noticeable; and a corresponding laxity and carelessness in practice, the results of which are too frequently lamentable.

It is said that, among the many religious sects of Russia, there is one which holds that all disease is brought about by the direct and special interference of the Deity, and which, therefore, looks with repugnance upon both preventive and curative measures, as alike blasphemous interferences with the will of God. Among ourselves, the "Peculiar People" are, I believe, the only persons who hold the like doctrine in its integrity, and carry it out with logical rigor. But many of us are old enough to recollect that the administration of chloroform in assuagement of the pangs of childbirth was, at its introduction, strenuously resisted upon similar grounds.

I am not sure that the feeling, of which the doctrine to which I have referred is the full expression, does not lie at the bottom of the minds of a great many people who would yet vigorously object to give a verbal assent to the doctrine itself. However this may be, the main point is that sufficient knowledge has now been acquired of vital phenomena to justify the assertion that the notion that there is anything exceptional about these phenomena receives not a particle of support from any known fact. On the contrary, there is a vast and an increasing mass of evidence that birth and death, health and disease, are as much parts of the ordinary stream of events as the rising and setting of the sun, or the changes of the moon; and that the living body is a mechanism the proper working of which we term health; its disturbance, disease; its stoppage, death. The activity of this mechanism is dependent upon many and complicated conditions, some of which are hopelessly beyond our control, while others are readily accessible and are capable of being indefinitely modified by our own actions. The business of the hygienist and of the physician is to know the range of these modifiable conditions, and how to influence them toward the maintenance of health and the prolongation of life; the business of the general public is to give an intelligent assent, and a ready obedience based upon that assent, to the rules laid down for their guidance by such experts. But an intelligent assent is an assent based upon knowledge, and the knowledge which is here in question means an acquaintance with the elements of physiology.

It is not difficult to acquire such knowledge. What is true, to a certain extent, of all the physical sciences, is eminently characteristic of physiology—the difficulty of the subject begins beyond the stage of elementary knowledge, and increases with every stage of progress. While the most highly-trained and best-furnished intellect may find

all its resources insufficient when it strives to reach the heights and penetrate into the depths of the problems of physiology, the elementary and fundamental truths can be made clear to a child.

No one can have any difficulty in comprehending the mechanism of circulation or respiration, or the general mode of operation of the organ of vision; though the unraveling of all the minutiæ of these processes may, for the present, baffle the conjoined attacks of the most accomplished physicists, chemists, and mathematicians. To know the anatomy of the human body, with even an approximation to thoroughness, is the work of a life, but as much as is needed for a sound comprehension of elementary physiological truths may be learned in a week.

A knowledge of the elements of physiology is not only easy of acquirement, but it may be made a real and practical acquaintance with the facts, as far as it goes. The subject of study is always at hand in one's self. The principal constituents of the skeleton, and the changes of form of contracting muscles, may be felt through one's own skin. The beating of one's heart, and its connection with the pulse, may be noted; the influence of the valves of one's own veins may be shown; the movements of respiration may be observed; while the wonderful phenomena of sensation afford an endless field for curious and interesting self-study. The prick of a needle will yield, in a drop of one's own blood, material for microscopic observation of phenomena which lie at the foundation of all biological conceptions; and a cold, with its concomitant coughing and sneezing, may prove the sweet uses of adversity by helping one to a clear conception of what is meant by "reflex action."

Of course, there is a limit to this physiological self-examination. But there is so close a solidarity between ourselves and our poor relations of the animal world, that our inaccessible inward parts may be supplemented by theirs. A comparative anatomist knows that a sheep's heart and lungs, or eye, must not be confounded with those of a man; but so far as the comprehension of the elementary facts of the physiology of circulation and of respiration and of vision goes, the one furnishes the needful anatomical data as well as the other.

Thus, it is quite possible to give instruction in elementary physiology in such a manner as not only to confer knowledge, which, for the reason I have mentioned, is useful in itself; but to serve the purposes of a training in accurate observation, and in the methods of reasoning of physical science. But that is an advantage which I mention only incidentally, as the present conference does not deal with education in the ordinary sense of the word.

It will not be suspected that I wish to make physiologists of all the world. It would be as reasonable to accuse an advocate of the "three R's" of a desire to make an orator, an author, and a mathematician, of everybody. A stumbling reader, a pot-hook writer, and an

arithmetician who has not got beyond the rule of three, is not a person of brilliant acquirements; but the difference between such a member of society and one who cannot either read, write, or cipher, is almost inexpressible; and no one nowadays doubts the value of instruction, even if it goes no further.

The saying that a little knowledge is a dangerous thing is, to my mind, a very dangerous adage. If knowledge is real and genuine, I do not believe that it is other than a very valuable possession, however infinitesimal its quantity may be. Indeed, if a little knowledge is dangerous, where is the man who has so much as to be out of danger?

If William Harvey's life-long labors had revealed to him a tenth part of what may be made sound and real knowledge to our boys and girls, he would not only have been what he was, the greatest physiologist of his age, but he would have loomed upon the seventeenth century as a sort of intellectual portent. Our little knowledge would have been to him a great, astounding, unlooked-for vision of scientific truth.

I really see no harm which can come of giving our children a little knowledge of physiology. But then, as I have said, the instruction must be real, based upon observation, eked out by good explanatory diagrams and models, and conveyed by a teacher whose knowledge has been acquired by study of the facts, and not the mere catechismal parrot-work which too often usurps the place of elementary teaching.

It is, I hope, unnecessary for me to give a formal contradiction to the silly fiction, which is assiduously circulated by fanatics who not only ought to know, but do know, that their assertions are untrue, that I have advocated the introduction of that experimental discipline which is absolutely indispensable to the professed physiologist, into elementary teaching.

But while I should object to any experimentation which can justly be called painful, for the purpose of elementary instruction, and while, as a member of a late Royal Commission, I gladly did my best to prevent the infliction of needless pain for any purpose, I think it is my duty to take this opportunity of expressing my regret at a condition of the law which permits a boy to troll for pike, or set lines, with live-frog bait, for idle amusement, and, at the same time, lays the teacher of that boy open to the penalty of fine and imprisonment if he uses the same animal for the purpose of exhibiting one of the most beautiful and instructive of physiological spectacles, the circulation in the web of the foot. No one could undertake to affirm that a frog is not inconvenienced by being wrapped up in a wet rag, and having his toes tied out; and it cannot be denied that inconvenience is a sort of pain. But you must not inflict the least pain on a vertebrated animal for scientific purposes (though you may do a good deal in that way for gain or for sport) without due license of the Secretary of State for

the Home Department, granted under the authority of the vivisection act.

So it comes about that, in this present year of grace 1877, two persons may be charged with cruelty to animals. One has impaled a frog, and suffered the creature to writhe about in that condition for hours; the other has pained the animal no more than one of us would be pained by tying strings round his fingers, and keeping him in the position of an hydropathic patient. The first offender says, "I did it because I find fishing very amusing," and the magistrate bids him depart in peace; nay, probably wishes him good sport. The second pleads, "I wanted to impress a scientific truth, with a distinctness attainable in no other way, on the minds of my scholars," and the magistrate fines him five pounds.

I cannot but think that this is an anomalous and not wholly creditable state of things.—*Nature.*

COSMIC AND ORGANIC EVOLUTION.

By LESTER F. WARD, A. M.

THE evolution of a world is not obviously identical with the evolution of an organism. From one point of view they may be regarded as, to a certain extent, opposite processes. Fully understood, they are different manifestations of one process, affected by very different circumstances. Regarding each as an aggregate which must equally run its course, the special histories of the two are quite unlike. The history of every aggregate consists of two parts, a rise and a decline. It has its period of growth and its period of decadence. The first consists in a gradual progress from a diffused toward a concentrated state; the second is the return from the concentrated to the diffused state. The process involved in the first period is the integration of the matter of the aggregate, and the dissipation of its motion. In the second period this process is reversed: its matter is disintegrated, and motion is evolved. The first of these processes is termed evolution; the second, dissolution. In theory this is identical in all aggregates, and therefore the life-history of a plant is the same as that of a star.

But, while we may trace and understand the process in the former of these aggregates, and may declare such to be its law as the result of more or less accurate experimental proof, this is not the case with the latter. We see the varied forms of life spring into being and vanish out of being. We may watch them during their entire history, from the moment when they emerge from the imperceptible to that in which they are again lost in the imperceptible. We can ob-

serve all the processes of concentration, of differentiation of parts, and of integration of the whole, as well as those of equilibration, of decomposition, and final dissolution. Not so with the planet. Whatever theory may suggest or require, we are forced to confess a profound ignorance of the final destiny of worlds. So far as we are able to observe, the universal tendency of all matter is from the indefinite and homogeneous to the definite and heterogeneous; from a state of unstable to one of stable equilibrium. But this is only the morning of the life of any aggregate. We have no reason to suppose that, in all the myriad worlds of visible space, a single star presents to our gaze a condition representing the evening of its life. In the light of all our knowledge of the heavenly bodies and of the nebulæ, we study with absorbing interest the history of our own planet. From the confused gaseous condition in which it is supposed to have originally been, its motion has been gradually dissipated and its matter integrated, until only a comparatively thin envelope of gas—the atmosphere—remains. The rest has all assumed either the liquid or the solid form, the latter of which presents the nearest approach to complete stable equilibrium. And it can scarcely be doubted that this process still continues, and will continue, until ultimately this omnipresent *eremacausis* shall also reduce the waters and the atmosphere to the condition of stability and solidification—a state of planetary existence which many suppose our satellite to have already reached.

And may not this same law be called in to explain the heterogeneity of elementary matter, as known to chemistry? If all matter is primordially identical, as so many philosophers have dreamed, is it not philosophical to assume that our sixty-five known elements represent so many states of heterogeneity, so many distinct kinds of primary aggregates, which the matter of our globe and other worlds has taken on in its course from complete homogeneous instability toward its ultimate condition of stable equilibrium, as represented in what we know as solids?

However this may be, it is at least true that, so far as regards purely cosmical processes, the ascending series is the only one observable by us. For the "dead star," be it understood, represents, in the grand cycle of the redistribution of matter and motion, the *meridian* of its life, and not its close. Complete equilibration is the last act in the drama of evolution, and must be attained before the forces of dissolution commence their work. But we look in vain for any signs of the dissolution of the universe. Whatever theory may require, the fact ever remains that the process which we see going on in our portion of space is the process of evolution only. We see only the integration of matter and the dissipation of motion. We see only the tendency toward the condition of stable equilibrium. We see only the absorption of the gaseous and the establishment of the solid form of matter. All the theories by which it has been sought to compen-

sate for the radiations of luminous bodies have proved mere speculations. We know that the sun is radiating its heat into space; we do *not* know that space is returning this dissipated motion, either to the sun or to any other centre. We see planets and stars in various stages of their progress toward the stable state; we have no reason to believe that any are in the condition of transition from the stable to the unstable state.

The moon is supposed to have already passed through most, if not all, of its stages from the gaseous to the solid condition. Its atmosphere has been absorbed, its waters have retreated into its interior or perhaps been converted into solids, and all its visible activities have apparently ceased. If there still exist volcanic activities upon it, as certain observations seem to prove, they are probably the only ones, and are themselves declining. Doubtless there are other bodies in our solar system whose equilibration is even more complete than that of the moon—as, perhaps, some asteroids, or the satellites of the outer planets. They have run their long cosmical course, and have arrived at last at the final state of complete, stable equilibrium. This state is the goal of the whole process of evolution. It must, therefore, be regarded, when viewed from this standpoint, as the state of greatest perfection in the life of every aggregate. Many of the heavenly bodies have certainly advanced far toward this condition, and all are undoubtedly approaching it. But where is the evidence that any have commenced to reverse this process? What star is suspected of being in a state of disintegration? Where in all the universe do we see solids turning into liquids, and liquids into gases? Where and how are the radiations emitted by concentrating bodies being harvested again, and applied to the disintegration of completely integrated matter? In a word, amid all these manifest proofs of evolution, what proof exists of dissolution regarded as a cosmical process? We are bound to confess that there is none. We are justified in its assumption on *a priori* grounds alone, if at all. The law of the conservation of energy, now so well established in all the departments of physics, must be theoretically extended to the mechanics of space. This law is only another expression for the indestructibility of motion. If no motion can be destroyed, the same quantity must always exist in the universe. And as motion is necessarily nothing more than the local change of material atoms, all the solar and astral radiations must continue for all time to affect the same quantity of matter to the same extent. Hence these radiations cannot be wholly lost. Still, all this may be true, without affecting the question of the dissolution of worlds. The minute fraction of the sun's heat which is intercepted and absorbed by the different bodies of the solar system is utterly insufficient to ever effect their disintegration; and it is continually diminishing as the sun itself approaches the term of its existence: *a fortiori*, no such results can ever be produced by any of the more remote

radiating bodies. All this motion is projected into space, and the history of its future work is wholly beyond our comprehension. It may continue to affect the ethereal atoms pervading space for all eternity, without exerting an appreciable influence upon concentrated matter. Even our right to project the law of conservation into the realms of space, where we daily see motion dissipated but never recomposed, has been called in question. Have we the right to assert that this motion, lost to our system, is not lost to the universe? True Science well knows how here to suspend its judgment, but it also knows how to restrain the hopeless cry of *ignorabimus*.

Mr. Herbert Spencer is therefore right in making evolution the fundamental principle of philosophy, and regarding dissolution, which is its exact opposite and correlate, as practically of very inferior importance. For, so far as the earth itself and the heavenly bodies are concerned, the very existence of such a process is in doubt. So far as our knowledge of the universe, as such, extends, but one law is anywhere observable, and that is the law of evolution. Indeed, evolution is but the process of which the principle is gravitation. Evolution is the concentration and integration of matter; its tendency is toward the condition of stable equilibrium. The *con*traction of a body is due to the *at*traction of its molecules. Gravitation alone can explain this tendency, and gravitation necessarily requires it. Evolution is therefore coextensive with gravitation. Wherever gravitation prevails, evolution must prevail. On the contrary, a condition of dissolution would require the prevalence of a force the reverse of gravitation—a repulsive and expansive force. Our acquaintance with the visible universe reveals no region of space where we can assume the prevalence of such a force. On the contrary, many fixed stars, and even nebulæ, afford the strongest evidence of being under the dominion of an attractive force. Not, however, but that there exists in the universe abundant evidence of the possibility and reality of a repulsive or dissolving force. This is found, and with the greatest certainty, within the scope of our daily observation of the facts about us. And in at least one instance it is assumed, with a high degree of proof, to manifest itself in regions beyond the limits of terrestrial influence. I refer to the behavior of the tails of comets at perihelion. But wherever we see this force of repulsion, which alone could effect the dissolution of the aggregates already formed, it is wholly subordinate to the force of attraction which has formed them. Phenomena of this nature are but episodes in the history of a system or of a world. Everywhere the opposite phenomena predominate. Everywhere the force of gravity is evolving new aggregates, and bearing old ones on to their final state of complete equilibration.

Let us now turn to the second branch of our subject, and glance for a moment at the phenomena and laws of organic evolution. The first fact that presents itself is, that its primary condition is the influ-

ence of the sun. However it may have been at one period of the history of the earth, when its internal temperature may have been of a nature to favor the development of organic life without the sun's aid, by the earth becoming itself a sort of sun, it may at least be now affirmed that the solar radiations are the sole condition of vital existence on the globe. This fact is so apparent that even savages have generally recognized it, and science has scarcely been able to qualify the popular conception. By the aid of the sun's heat and light the various forms of vegetable and animal life have been evolved. By the same influence, year by year, the buds, and flowers, and leaves, unfold to the elements, and renew their conditions of growth and reproduction. By means of it the waters of the globe are in part converted into vapor and gas, in which state alone they are adapted to the supply of organic beings. By its influence the various organic bodies on the surface of the earth are finally disintegrated, and the materials for new forms and new beings are dissipated into the gaseous form, for recomposition and reutilization. By the same influence the waters of the globe are prevented from solidifying, and made the abode of millions of organic beings. In a word, it is the influence of the sun which alone renders our planet a habitable globe.

But what is the nature of this great and wonderful influence as expressed in the terms of the redistribution of matter? However paradoxical it may seem, it is nevertheless true that the great life-creating and life-sustaining force of the sun is cosmologically a *disintegrating* force, a force of *dissolution*. Indeed, the solar and sidereal radiations are the only examples which the whole universe presents to us of such a force. It seems strange enough to be compelled to ascribe all the phenomena which have been embodied in the term organic evolution to the action of a force which is the precise opposite of evolution, and which ultimately accomplishes the dissolution of every such aggregate. Yet it is only because the sun is in a state in which its matter is being integrated, and its motion radiated into space, that our earth is capable of producing the forms of organic life. It is only because a portion of this motion, ejected from the sun, is intercepted and absorbed by the earth, by which a portion of its own matter is disintegrated, and its own course of evolution is in so far arrested that the presence of the beings peopling it has been made possible. It is only through cosmical dissolution that organic evolution can go on.

Is life, then, a process of dissolution? Is organic evolution a misnomer? Are the unfolding of the bud, the branching of the tree, the hatching of the egg, the differentiation of the animal—are these but so many steps which concentrated matter is taking toward its final disintegration? Is development the antithesis of evolution? To all these questions a negative answer may, I think, be given. But we have gone far enough to perceive that some broad distinction exists between

cosmic and organic evolution. Let us examine this distinction more closely. We know that an organism develops, much like a world, out of an homogeneous and diffused state of its elements. Throughout its course the organic aggregate behaves like other aggregates. From the imperceptible it becomes perceptible. From the diffuse it becomes concentrated. From the indefinite it becomes definite. From the homogeneous it becomes heterogeneous. From the unstable it approaches the stable condition. Segregation, which is the selective process, is more marked in the organic than in the inorganic aggregate. Its parts are differentiated and rendered distinct and definite, while through an increasing dependence between them the whole aggregate becomes more and more firmly integrated or consolidated. Growth, which is increase of bulk, is simply the absorption of diffuse gaseous or liquid materials, which may theoretically be regarded as having originally belonged to the aggregate in its most widely diffused condition. Development, which is increase of structure, is the same process which all aggregates undergo in their transition from the homogeneous and indefinite toward the heterogeneous and definite, under the laws of segregation and the multiplication of effects. Finally, equilibration in organic aggregates is distinct and universal.

Every organism must reach this stage, and that in a comparatively brief period—so brief as to be capable of repeated and easy observation. So plain does this stage of its progress become that it is feared that the predication of a stage of equilibration, not to say dissolution, for inorganic aggregates, is an argument from analogy, where the analogy is taken from a very subordinate class of phenomena, viz., from the observed equilibration of organic aggregates. A universal conclusion is deduced from a particular case; the law of the whole is assumed from that of a part. This, according to Mr. Spencer's own showing in his "Principles of Psychology," is the weakest form of reasoning. It should be admitted, however, that while the doctrine of the ultimate disintegration and dissolution of the celestial bodies rests on very insufficient inductive evidence, there are strong *a priori* grounds, beyond the domain of science, but clearly within the range of philosophy, which make it a legitimate object for the exercise of the "constructive imagination."

The most important truth which can be called in to aid us in this difficulty and apparent confusion of phenomena is that of the perpetual competitive operation of both the forces of evolution and of dissolution. Both these influences are at all times and in all kinds of aggregates simultaneously at work. The history of every aggregate is that of its struggle with these opposite contending influences. The final equilibration implies this. It is the establishment of equilibrium between just these forces. In the evolution of a star the forces of dissolution are mostly within the aggregate. In that of a star-system they seem to be wholly so. The process of evolution goes on against

the inherent tendencies to dissolution. The equilibrium reached is between the attractive or integrating and the repulsive or disintegrating forces. Both are at all times active, and, if the latter at last prevail and the mode of redistribution is reversed, the gravitative influence still continues to oppose its progress. In an organism the disintegrating tendencies are chiefly from without. Everywhere on the globe the sun's influence is tending to prevent the integration of the liquid and gaseous elements. Life is the product of this struggle.

It may be laid down, as a universal law of the redistribution of matter, that organization is the product of the antagonistic tendencies of attraction and repulsion during the period in which the former prevails. Organization is, then, the great distinguishing characteristic of the process of evolution. The organization of the solar system is the result of this competitive struggle between these two agencies. It is the same with an organism. We have, then, at last reached a plane of generalization in which the cosmical and the organic processes may be regarded as parallel and homologous throughout. The active principle which directly results in organization is that which Mr. Spencer denominates *segregation*, by which the like parts are brought together and unlike parts separated.

The final result of this process is the formation of many distinct and definite parts which are unlike one another—heterogeneous. Each of these definite parts, differing from all the rest in the same aggregate, is, within itself, homogeneous, i. e., consists of a uniform internal structure. The like particles, in consequence of the similarity of their properties, naturally gravitate to the same place. In the case of the earth the atmosphere or gaseous portion forms a uniform envelope around it, due clearly to the nature and homogeneity of its molecular constitution. The waters, for the same reason, form a partial second envelope within this. The hardened crust of solid matter comes next, and in like manner the entire organization of the earth might be explained. Exactly the same process takes place in a living organism. Its various organs, vessels, specialized tissues, and differentiated parts, are the result of this same law of mechanical selection. The difference in the properties of the matter of each is at once the cause of their segregation and of their organic function.

The point at which we have arrived, therefore, is this: Organization is the necessary consequence of the competition of the integrating and disintegrating forces, so long as the former prevail. The influence of the sun upon the matter of the globe is toward its disintegration and dissipation into gas. But for the opposing influence of gravitation, attraction, or concentration, this result would be speedily accomplished. But the resultant of these two antagonistic forces, at a time when their relative power is substantially what it now is on the surface of our globe, is such as to render possible the form of evolution which we denominate organic life. A certain amount of the

matter of the globe is in the gaseous form. The gases themselves are differentiated into what we call oxygen, nitrogen, carbonic acid, and aqueous vapor, each of which exerts its special influence in the economy of vital existence, and without any one form of which, so far as we can see, life would be impossible. Another portion of the matter composing the earth exists in the liquid state, the chief form of which is water, of which more than half the weight of all organized beings consists. Evidently without water nothing answering to our conception of life could exist. Of the solid matter of the globe there exists the greatest heterogeneity, and it may be classified in a variety of different ways. Many, though probably by no means all, of the so-called distinct substances known to us are of direct value in the formation of organic tissues, and certain of them are clearly indispensable, so far as we understand their office; as, for example, lime, phosphorus, iron, etc., etc. Certain of these substances are crystalline, others colloid in their structure, the latter of which possess peculiar adaptations to the formation of organic tissue. Finally, between the solid and the liquid state there exist all grades of transition, thus adding variety to the organic adaptations.

As the universal law of concentration or integration proceeds to reduce all these varied forms to one, and to cement all in a single homogeneous solid, it is met by the powerful but somewhat irregular and erratic force of the solar radiations, reënforcing the inherent cosmical influences already so far overcome in the evolution of the planet as to have brought it to its given state. The result of this conflict of forces is the condition in which we find our globe. Without the aid of the sun's rays, organic evolution might have been impossible. Without the aid of the cosmical force of concentration, in a certain way counteracting without neutralizing them, it would have equally been impossible. With such a predominance of the one as has probably prevailed in the past, or of the other as will probably prevail in the future, the particular form of evolution required to develop what we know as life seems also beyond the range of scientific probability. A few degrees more either of heat or of cold are sufficient to utterly destroy it. Of the latter, we have a near approach to a positive example in the state of things existing in regions round the poles of the earth's axis. Of the former, artificial proofs are easy, and certain desert regions of the globe constitute partial illustrations, easily completed by the imagination.

We thus learn what a precarious thing life is, within what narrow limits it is circumscribed, upon what slender conditions its possibility depends; contemplating which, we may be appalled to reflect how small a portion of the concentrated matter of space must be presumed to fall under these conditions. For, even if every world in space passes through this organic period, its duration must be ephemeral compared with the vast cycle of its existence.

The important truth that it has been sought to reach by these considerations is, that organic evolution is but one of the minor manifestations of universal evolution. It occurs at a stage of the process when the struggle between the contending forces is very great, if not at its greatest. It is the immediate product of that struggle, and cannot exist when either the one or the other greatly predominates. The force to which we universally ascribe all possibility of life is the force which is tending to disintegrate the matter of the globe by absorbing the motion of the sun. The force which constitutes evolution proper is that which bears down all life and reduces the face of Nature to a desert waste. The interaction of these two forces, where they are suitably proportioned, effects the organization of portions of the matter on the globe, and organization itself is life. The period of greatest organic perfection on a planet is therefore very different from the period of its greatest cosmical perfection, which corresponds with that of complete equilibration. Cosmical evolution is the history of the universe, organic evolution is a transient episode in the life of a paltry planet. We can only console ourselves with the belief that, but for this trifling digression of Nature, no being would have existed capable of formulating the laws of the universe.

Organic evolution must not, however, be restricted to the mere span which the life of an individual represents. To fully comprehend its scope, the conception of the organic aggregate should be extended to embrace all the life, past, present, and future, on the globe. The mysterious process of reproduction, unknown to all other aggregates, has the effect of binding all living organisms into one continuous whole, and giving to all terrestrial life the stamp of unity. The individuals of a race or species do not represent so many distinct aggregates. The qualities of antecedent forms, whether inherited or acquired, are transmitted to subsequent forms, thus conserving, as it were, all the organization previously evolved. Although the dissolution of the individual aggregate takes place, the work of evolution which has been going on within it is passed on to a new generation, to be there continued and again transmitted. The individual, therefore, becomes of comparatively small importance. The real organic aggregate is the race. The race alone is capable of receiving and preserving all the products of organic evolution. Ontogenetic development is lost sight of in the march of phylogenetic development. The individual is merged in the species, the species in the genus, the order, the class, and all are finally swallowed up in the *tout ensemble* of organized existence. Organic being, as such, is the final term to which the generalization must be carried before the true scope of organic evolution can be adequately grasped by the mind. Individuals perish and are decomposed; species become extinct; genera, families, and whole classes, are swept from the earth. The broadest divisions into which the organic kingdoms of Nature have been classified have each their

periods of ascendency and decline. But organic evolution ever continues. Progress in organization is the constant result. It is always, on the whole, the less organized that gives way to the more organized. If the rich and exuberant cryptogamic vegetation of the Carboniferous epoch has dwindled away into the insignificant cryptogamic vegetation of our time, it has been succeeded by a phænogamic vegetation of far higher organization and nobler qualities. If the great saurian dynasty that ruled the Cretaceous age has surrendered its sceptre and disappeared from the stage of terrestrial life, a far higher mammalian dynasty, at whose head man now stands, has taken up that sceptre and is moving on to still loftier heights of organic development.

We have thus arrived at the highest point from which the phenomena of organic evolution can be surveyed. What do we see? We see that, in proportion as our point of view rises, the relative importance of the phenomena of dissolution to those of evolution diminishes. We see that the dissolution of the individual aggregate affects but little the evolution of the race-aggregate, and not at all that of the complete life-aggregate of the globe. We see that, amid all the evanescent forms that surround us, the evolution of life is constant; that of organic being as such there is no dissolution. We thus find the parallelism between cosmic and organic evolution, which at the outset seemed so paradoxical, and afterward so imperfect, to be at last complete. In the one as in the other, the only phenomena which we know to be universal are those of evolution. In the one as in the other, the opposite class of phenomena are wholly subordinate, special, and local. In the one as in the other, the forces of attraction and repulsion, of integration and disintegration, are in perpetual conflict. In the one as in the other, the organization of matter is the result. Just as the doctrine of the ultimate dissolution of the bodies of space rests on *a priori* deductions alone, unsupported by empirical observation, so must the final disorganization of the life of our globe be inferred from cosmological principles, which transcend the present limits of astronomy and physics. So far as we are capable of penetrating the mysteries of space or of life, we find that evolution is the law of the universe; while the forces which oppose that law, though powerful and ever active, are secondary and subordinate, and only seem to reverse it by the destruction of transient forms. In the genesis of world-systems this counter-evolutionary force consists in the inherent expansive power of diffused matter, or, what amounts to the same thing, in the resistance which such matter offers to the forces of condensation. In the phenomena of life this resistance comes chiefly from the sun, whose thermal radiations tend to dissipate the elements of the globe.

We are thus brought into full view of the deepest truth that underlies the redistribution of matter—the profound antithesis be-

tween *gravitation* and *ethereal vibration*, which constitute, in the last analysis, the true correlative *principles* of which evolution and dissolution are the corresponding *processes*. These are the agencies which are at all times antagonizing each other in all parts of the universe, and whose exact equality in it seems to form a logical tenet of the modern cosmology. A certain golden mean between these forces, but in which the former must predominate, results in organization; star-systems are formed in space, and life is developed out of the planetary elements. Such appears to be the state of all the matter within the range of human observation. For, whatever may be the condition of other worlds or other regions of space, the phenomena of our world and our portion of space belong to the ascending series; and whatever may be the final doom of our planet and our universe, both are now in a state of progress, and are still rejoicing in the morning of creation.

PESSIMISM AND ITS ANTIDOTE.

By CHARLES NISBET.

THE consideration of general questions not admitting of definite answer, and always throwing us back on the consciousness of the extreme limitation of our knowledge, is not a profitable direction of mind, nor to be recommended as an exclusive study.

Still, occasionally, it may be wholesome, as it has confessedly a strange attraction for us, to journey to the confines of our little island of knowledge, and thence speculate a little on the trackless ocean of mystery to the navigation of which science and logic are alike inadequate. All true religion is founded on this consciousness of the infinite, of an ultimatum transcending our comprehension, but stimulating and exercising our faith.

The moral government of the world, the spiritual tendency, or indeed any dominant direction, of things, is not patent to the fleeting glance, does not reveal itself even to the most strenuous thought. The history of the world presents itself rather as a Jeremiad, as a bottomless chaos in which evil and good wrestle with each other for the mastery, and where evil generally boasts the vast majority of forces.

Savage countries lie thousands of years morally stagnating or decomposing, often physically starving, ground down under cruel despotisms and superstitions, reducing one another in perpetual warfares. The pages of the most favored countries show long chapters of declension, and the moral influxes, like angels' visits, only few and far between. The cause of Brutus opens the way to Cæsarism and death. Spain shares in the tide of new life, but that life is zealously extin-

guished, and the nation settles down to decay. Cromwell and his Puritanism introduce Charles II. and licentiousness. The Pilgrim Fathers, Washington, and other great men, lay with solemnity and greatness of mind the foundations of the United States, and is its history hitherto a satisfactory result? Nation after nation, Egyptian, Persian, Jewish, Grecian, Roman, Arabian, and Celtic, shoot into blossom in order to rot back into forgetfulness.

And if we take regard of the individual units that are always swarming by the millions into the world, what vast quantities get blasted out before they have well begun to cry, not to speak of the possible units frustrated of birth. And of those surviving the perils of the outset, how all get bruised and damaged sooner or later, till death comes and snuffs out the smoky tallow-lights! People made a great fuss at the time about the late William King Thompson, of Brooklyn, New York, ship-exploder, as if he had done something more than usually wicked, but now it is seen for the mere trifle it is. Say he exploded half a dozen ship-loads of men, was there, out of the six human cargoes that flew successively all at once into ten thousand pieces, as much as *one* individual that properly speaking ever lived, or lived other than the most insignificant sensational existence? At every change of the temperature of the atmosphere from heat to cold are not many thousands of aërial midges summoned, on very short notice indeed, from their gay discursions to face the solemnities of eternity? Animal existence is cheap as dust, the earth and stones only requiring some little mixing and kneading in order to turn off endless batches of men and women.

Consider the tens of thousands always being born in our large cities, who by bad parentage, bad conception, foul air, foul food, and all manner of evil influences, get at once summarily stamped and sealed off to depravity and perdition. Think how in all our towns are houses where choice human cattle are kept, fed, and dressed, their soundness attested (on the Continent) by qualified officials; and how your choicest human cattle, rejoicing in their spiritual culture, throng into these shows to inspect and purchase. And in this enlightened age we know this is Nature all the world over, and Nature must be obeyed.

We are proud of the present age as the triumph of trade and mechanism. And we know the high genius and aim of trade. Trade thinks only on a good balance, and is proud of a good balance, be it got out of the follies and vices of men or in whatever way. Trade is thinning the country, crowding the towns, swelling dukes' incomes, fattening distillers and brewers, disfiguring and reducing the human *physique*, blighting the tenderness of relations between man and man, checking you off the values of the different sorts of intellect and inspiration. And, thanks to the extreme nicety of our mechanical arrangements, we are cut down into the most fractional existences. As if the *disjecta membra* left on a field of battle were made to spin into

some sort of galvanic life! In the higher provinces, too, your intellectual men are distributed into departments and sub-departments as writers or speakers, while life in the walks of fashion is a game of consumption and show. And when on the part of busy men the day's arduous endeavors toward the continuance of sublime human life are accomplished, and leisure is left for reflection, then a glass of beer, a pipe, cards, coffee and cake, a game at billiards or whist, a novel from the circulating library, is illimitable scope for the spiritual faculties.

And if we turn to our highest spiritual institutions we see equal signs of prosperity. At all our famous universities droves of young men called "students" are invited to profane the holiest names and symbols under the pretext of studying them, as if the first and foremost condition to intellectual activity or "study" were not a certain degree of spiritual faculty, of purification of the heart. The towns where they are collected for spiritual culture they defile more scandalously than any other class which makes no pretensions to spiritual culture.

Even if we single, out of the whole range of human history, the few men of genius whom we are constrained to regard as the eminently favored and endowed of our race, we find what a broken career has been allotted to the most of them. Have not many of them, possessing courage to inspire, intelligence to enlighten, sensibility to refine the world, sickened under the languor of neglect or got embittered at the endless contradictions and misrepresentations of their fellows, dying at last as unfortunate men, unhappy to themselves, unbeneficial to their contemporaries? What an evil is the not unfrequent depravity of genius, and which under happier circumstances might have been a great salutary influence instead! Might not the tremendous forces of Swift, for example, have been turned to better account than left to explode in shocks of half-diabolic hate in earlier days, and in madness at the end? Think of the generous human heart, brave will, and clear head of Burns, a man of quite transcendent powers, yet fain to slink past on the shady side of the street, left to bleed so wretchedly to death in the midsummer of his days. Contemplate the great intellect and great heart of Lessing, a man of thrice excellent mother-wit and effectiveness, disposing with a lordly air of the whole literature of Europe, awakening with his clarion-voice his slumbering nation to new intellectual conquests, yet himself imprisoned for so many of his best years in the stifling library-dust of Wolfenbüttel, isolated there in the midst of an unhealthy swamp; the world such a dish of skimmed milk as to be incapable of any sense of honor. Was not Lessing's child a boy of remarkable sense, who no sooner came into the world than, seeing his mistake, made out of it double-quick? Is it not probable that many brave souls, braver and better perhaps than any known to fame, have gone down to silence unregarded, the world's stupidity being more than a match for the gods themselves? Think of good

Edgar in "King Lear," and had he been left to die a maniac, would that, think you, have been untrue to fact?

Even the one or two to whom Fate has been most propitious, a Shakespeare, a Goethe, have not they too suffered from the bruises or flattery of Fortune, fallen at any rate far short of the fullness and balance a happier age and education might have conducted them to?

People are indeed fond of raising monuments and holding centenaries (to the so-called honor!) of great men, but do you think there is any significance at the bottom of it? Very little indeed. The fathers kill the prophets, and the sons garnish their sepulchres.

In the face of these facts and considerations how disgusting to hear the universal cant about "public opinion!" The shoemaker's opinion may indeed have some value on the matter of boots, the tailor's on that of clothes; but what opinion can the masses, all absorbed in the question of simple existence, have about government and education and religion? At best they are capable of a total heart-belief in *names*, of dying as martyrs for *names*. Dean Stanley admits that most of the noble martyrdoms have been in attestation of peculiar combinations of letters of the alphabet. See the intellect and heart of Scotland wrangling, down into the latter end of the nineteenth century (and into how many later centuries?), as to whether little children at school shall learn how to define effectual calling and distinguish between justification, adoption, and sanctification!

And all men shall be immortal? Each despicable unit must needs be an immortal and independent soul? Came from God? And God sends by special appointment such swarms of immortal souls, often in such questionable way, sinto the world? And if you are really eternal the *one* way, *before*, you must also be so the other way, *behind?* What, then, of your being a thousand years ago? And you do seem to carry the air of eternity about you, sleeping and digesting and pottering about nothing as you do! Is not each individual man, according to Darwin and Haeckel, but the temporary inheritor and transmitter of the qualities of his ancestors, modified by the impressions received during his own tenure of life from intercourse with people, reading, etc.? And how can the self-same life be held at one and the same time by each individual successive link in an endless chain, seeing the life devolves but in succession, and that each link in the chain sparkles into existence and luminousness only during the short term of actual possession?

It is no use arguing that men are left to their own free-wills, and have themselves to blame for their fates, when the whole complaint is simply that men have no free-wills to be left to, but are total slaves. And yet not a poor devil desecrating the earth but, under very possible circumstances, through a kinder providence and better influences, might have been saved in the first place from being born a devil. Where, then, is the moral government of the world, the ideal tendency

of things, the high and lofty destinies, and all that? Schopenhauer and Bahnsen, earnest thinkers, arrive, after exhaustive examination and mature deliberation, at the conclusion that the world is not the best but the worst conceivable, the best possible issue for it annihilation, man's greatest misfortune birth, his greatest happiness death.

And yet the everlasting impossibility of accepting this as a final statement proves unquestionably its partiality—proves there must be quite a different and broader verdict. *Dum spiro spero;* respiration is aspiration. Life is hope, is struggle upward and onward. Healthy and robust life can set no final goal to its endeavors and hopes, but carries deep in its bosom the promise of quite an infinity of inheritance—dim and unconscious perhaps, yet latently warm and unquestioning.

Despair is death, declension from once recognized higher ideas is degeneration, violation of principles of honor and justice once recognized is inevitable injury. In the active furtherance of spiritual or universal ends alone has man solid and complete satisfaction. What is the meaning of the universal Jeremiad from the beginning of time till now but "the fall," the declension from the necessary justice and goodness? Down to the last stage of depravity the man is never at home in his depravity. It is always *de*pravity, and not native badness. The man's unsightliness, alienation from himself and his fellows, inward sense of bankruptcy and ruin, is an eloquent, pathetic sermon in behalf of the true. Injustice, selfishness, disavowal of obligations, seizure of others' property, never enriched or profited a man, but has always been so much inward contraction, induration, plethora, deliration—always so much disease involving so much pain, demanding so much expiation.

The subordination of self in the pious recognition of the eternal laws (= religion) and the adequate willing execution of the same (= art)—that alone is life, and a man is more or less according to the measure of his possession of this life. In the name of God, which is our highest expression of the world, is recognized something higher than our utmost sense of the just, good, and beautiful. If, then, our hearts go out in fervent, irrepressible longings of love toward the great men who have met on this planet the most unhandsome reception, if we demand that the heavy debt of love and esteem which was due to Lessing, for example, but never paid, be at last made good to him, that this excellent spirit, which out of a full heart would radiate to the quickening and enlightening of his country and Europe, do not strike his beams into emptiness, but that he himself also be gladdened by the warm reflection of his own light—is there, are we to suppose, nothing in the heart of things, nothing in the primal intellect and heart corresponding to this unsubduable demand on the part of our remote individual consciousness? Shall the mother-sun be less warm

than a reflex ray of itself? If, again, our hearts, though so poor and insensible, can yet break in salt sorrow over the confused helpless misery of the masses, is the prayer that bursts involuntarily from them not in accord with the heart of God himself? Is it a foolish and false impulse which Nature stirs in the heart of the mother when she recognizes a quite infinite value in the poor helpless chick newly-born to her? When Jesus Christ appeared as a symbol of love and mercy in this world, preaching the prodigal son, and proclaiming the God of this world to be a God of righteousness and compassion, could the hearts of his hearers remain insensible to the manifestation and the sermon? Have not the words been caught up as the truest gospel of the highest God? And in Jesus Christ, who felt an unspeakable interest even in the outcasts of society, and whose attitude toward the morally wrecked man, in whom desires and appetites had devoured all the handsome capital and prospects and possibilities in life, was *not* the side sniff of cold disdain, but condemnation into everlasting fire or an infinite yearning of compassion—in this appearance of Jesus Christ on earth have not men been constrained worshipfully to recognize the truest incarnation of God? Religion which sinks in us all personal regards, which would bring us into immediate communion with the Supreme, is ever a consciousness of inexhaustible resources—is more than a counterpoise for all the ills of life, and all the black facts which history can adduce—is a power which can dwarf all history, all the hitherto actual, into the insignificance of a mere prelude, and not an essential act in the drama of life itself.

Meanwhile, over and above this general reflection, which, if needed, can always serve as our last impregnable resource, it is possible to predicate particularly some of the advantages, and even the absolute necessity, of the confusion and misery everywhere attaching to reality.

This confused world of good and evil is the right arena and training-school for battle, enterprise, patience—for all the active and indeed also all the passive virtues. The baseness, stupidity, folly, injustice, suffering, and wreck, this world everywhere presents, are always a splendid challenge to strength, diligence, endurance, faith, wisdom—to all sublime and manly qualities. Sloth, indolence, sweet dreaminess, and credulity, have a hard time of it here—meet every day with the shrewdest rubs and tosses till they are either forced into wakefulness or gored into death. A long-living and prosperous nation must plough the soil, must sail the sea, must live much out-of-doors, must ever be prepared to defend its own against the whole surrounding world. And the artist or man of letters must not ensconce himself too much in his cozy study, but lay himself open to the shock of opposition and the misconstruction of his fellows, must not shrink from the experience of unkindly facts to try his nerve and test his digestion. Only to the man who lives industriously, moderately, honestly, truthfully, and piously, does God vouchsafe higher dis-

closures; and to the man who will eat the bread that has been by the labor of other hands procured for him without paying an equivalent, the kingdom of heaven is forever shut.

The personal pain, languishment, and imbitteredness, do not spoil for the brave man his appreciation of life, but by persistent faith and well-doing he subdues and converts contrarieties into furtherances. Socrates and Paul and Cromwell and Milton did not break their hearts or give up the fight. Lessing, after all the languor and sickness of Wolfenbüttel, refused to die, though he bore in his heart the deadly ravages of fate, till he had first presented to his ungrateful country his large-hearted offering of "Nathan der Weise." Nor was he egoistically looking forward to a world of happiness beyond the grave, as compensation for his sufferings, as reward for his magnanimous services.

> "He heeded not reviling tones,
> Nor sold his heart to idle moans,
> Though cursed and scorned, and bruised with stones."

Think what sort of world it would be without the pain and persecution. When in our church-pews our ears are tickled with the sweet eloquence about heaven, where there will be no tragedy, no pain, no tears, no trial of temper, no tempers, no passions, no black, all white, only white, everlasting singing, and so on, does not every masculine heart feel the most melancholy misgivings about the concern? would he not willingly sell out on that policy even at a liberal discount, could he but invest with the realized capital in this troublous yet withal interesting planet?

The truth is, the mixture and antithesis is the appetizing quality in the fare of life. The dangers, misunderstandings, jealousies, errors, and seductions, on the one hand; on the other hand the joy in healthy relations to the sensuous world, and in the æsthetic contemplation of it, the sense of the ludicrous and ridiculous evermore tickled by the wonderful conjunctions of the sublime and vulgar in human affairs, the feeling of heaven in true relations to our fellow men and women, in work accomplished and duty performed, the highest bliss of all in the recognition of, and nearer and nearer identification with, the Supreme Spirit; the sense, in short, of a hell on the one hand to be shunned, and a heaven on the other to be enjoyed—whoever vividly realizes all this will not underrate life on this planet, but infinitely prize it.

Yes, this earth is dear to mortal men, not merely in spite of its tears and crosses, but also on account of them. The bitterest experiences we pass through need but to drift to the due distance in the past, and they assume a wonderfully interesting guise. Strangely, tenderly affecting in the retrospect are our riotous "Hal" days, our sighing Venus and Adonis fit, our sultry Werther fever, our sweet and bitter Faust period, and all the other dear illusions which beset us on our devious path.

For indeed we prize life not by the sum of our possessions, but only by the rate and steadiness of our growth. "Not the possession," says Lessing, "or fancied possession of the truth, but the endeavor after it, determines a man's value. If God held in his right hand the sum total of truth, and in his left the ever-inextinguishable desire after truth, though linked with the condition of everlastingly wandering in error, and called to me, '*Choose*,' I should humbly close with the left and answer: 'Father, give me this; the truth pure and simple is for thee alone.'"

But if we will have cleared to ourselves at the highest court what it is that imparts to error, crime, and tragedy, their powerful attraction, so that they are indispensable to high poetry and music and art, we shall find it is only because they constitute a dark background to heighten the play of the lightnings, to glorify the splendor of the sun. The trial and sorrow and humiliation serve to bring out in distincter outline the faith and serenity and triumph which, as in St. Paul, are more than a match for all the powers of darkness. Our conviction of the dominance and necessity of moral law is so deeply grounded, that the storm and earthquake threatening its upheaval only summon into livelier consciousness our inexpugnable confidence. Let the heavens fall. Though the earth be removed, God is our refuge.

It is the conscious or unconscious conviction of every sound man that truth is better and more beautiful than any delusion—that a man's well-being is the measure of his conformity to truth. Does a man find his hitherto solid philosophy impugned, his most holy religion out of joint with new emerging facts, he will not shut his ears to the severe reason. Does Science come and knock from under his feet the ground of immortality on which he had rested, it may help only to startle him out of his egoism—startle him on to some firmer footing. He must feel the immortality in the present, and not postpone it to the future. Only he who has eternal life in him (= intellectual recognition of, and hearty identification with, eternal law) is eternal. If Darwinism is true, and a man's spiritual supremacy is also true, the two facts will square with each other. For mind and Nature are the type and impression, in perfect correspondence to each other. The harshest exception is, when properly understood, no exception but a confirmation of the beautiful law. Depth and wholeness of vision will always be song and piety, be Dante and Shakespeare, never skepticism and mockery. The reconciliation of the spirit with Fate and Nature is a grace which rests sweetly and unconsciously in the heart of simple goodness, but is also the crowning grace of the boldest intellect which has pierced deep enough. Plato, Shakespeare, Milton, Newton, Kant, Goethe, and Schiller, are reverent worshipers, and walk in the sanctuary above arm-in-arm with Christ and the apostles. We see, in the "Nathan der Weise," how the brave Lessing received before death in fullest measure the gift of reconciliation.

And out of the perplexities and corruptions and misunderstandings of human affairs we have in Nature, which ever over-canopies and surrounds us, a retreat into the beautiful, where we can evermore refresh our sense and conviction of the holy. The sun, stars, woods, grasses, shells, birds, and wild creatures, are not corrupt, or at least do not suggest to man, when he contemplates them as a whole (æsthetically and not scientifically)—do not suggest images of corruption; but the poor besotted wretch beholds a perfect splendor in the sun, the prey of ruinous appetites looks into an eye of innocence in the flowers, the bankrupt gazes around and above him, and wonders why in a royal palace he should be a blot and disgrace.

As soon as the man rises above his desires, and throws the roots of his being beyond the narrow confines of his egoism into the spiritual realm, where his own individual self sinks in other individuals, where other individuals become as much his proper interest as himself, then the soul becomes one with the universal soul, and perfect reconciliation is enjoyed. The man's past pains are healed, his very sins and sorrows yield themselves to him as experience and instruction and romance.

The devil himself is subdued into good. Job's latter days are more beautiful than his early days. Through his sorrows and errors, Faust at last attains to a wider and holier life. The attraction to Gretchen, notwithstanding the sensuous illusions, has, in the heart of it, a soul of love and sacredness, and through the deep welter of sin and suffering is purified at last into sanctity. Do you think Faust in the end would annihilate his experience of Gretchen if it were possible? No, the earth and heaven are dearer because of her. Gretchen is universalized, and the universal is Gretchenized; the world is all a sacred, pathetic Gretchen.

That an unhappy life may be happier than a happy one is indeed a paradox, but is meant in earnest. A tragedy is more delightful than a comedy. Or a comedy is better for a mixture, and strong mixture, of tragedy, so the tragedy only get digested in the end. Black is necessary not only to the relief, but even to the very composition of white. I should not choose a life of uninterrupted pleasure, were the world to engage its utmost to secure it me. The lightning is born of the darkness; and the battle, joy, and splendor of life are to be measured by the amount of opposition overcome.

> "They say best men are moulded out of faults,
> And, for the most, become much more the better
> For being a little bad."

Let us with assured hearts trust the Cause of all, who has created the good and the evil, but has, we believe, made the evil to be ultimately subservient to the good.—*Macmillan's Magazine.*

THE MODERN PIANO-FORTE.

By S. AUSTEN PEARCE, Mus. Doc., Oxon.[1]

MUSICAL instruments with manuals or key-boards, and fixed tones, occupy a most important position in the annals of modern art. All the greatest composers have been skilled performers on such instruments, and especially on the piano-forte. They are very greatly indebted to it; not that their works have been produced by its aid, or that it has been allowed to exercise a formative influence over their imaginings, but because of its companionship and sympathy. The creator of new musical forms, while engaged in his silent work—in the comparatively slow process of writing the individual parts for all the instruments employed in the orchestra—not only exercises the faculty of expression, but also the power to withhold. This power—this muscular strength of the brain, to grasp and retain whatever has been conceived, notwithstanding the perplexity as to means of expression, which commonly attends a crowd of ideas and feelings—is sometimes in danger of being overtaxed. On these occasions great relief is found by opening the piano-forte, and throwing off the piece at full speed on this plastic instrument. After realizing his ideals in this immediate and satisfactory manner, the composer returns refreshed to his patient labor—to the detailed record on paper of those emotions which fill him with such passionate energy. Or, should he wish merely to find relief in utterance—to commune with himself, and obtain recreation by driving temporarily from his thoughts the work in hand—then this comprehensive instrument, this miniature orchestra, enables him to extemporize elaborate contrapuntal forms, clashing cyclopean harmonies, or highly-involved melodic strains. The sounds thus evoked fall back on his delighted ear, exhibiting to him, in audible form, his psychologic condition. During these fleeting moments he thus beholds his subjective state, as clearly and definitely as in a mirror he would see, similarly reflected in visible form, the expression of his countenance.

But the piano-forte, by making domestic music at all times easily and immediately attainable, without the preliminary adjustments required for the harp or other stringed instruments, has become universally popular. Its literature is larger than that of any other, and whatever musical forms have found favor with the public are immediately adapted and rearranged for reproduction on it.

The piano-forte appears in four principal forms: as grand, square, upright, and curved, the latter being a newly-designed model, by Mr. J. W. Otto, of St. Louis, Missouri. The American grand piano-forte

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is, however, the greatest triumph of inventive genius and skill, aided by modern physical science; and this fact being acknowledged in all parts of the civilized world, foreign trade has been introduced to such an extent as to make the industry one of the largest in the United States. All the makers here daily strive for preëminence, and endeavor to surpass one another in the superior excellences of the smallest details, if not in the novelty and value, of their own respective inventions. No pains or expense are spared to obtain improvements, in the hope that these may, at least, lead to subsequent discoveries in the many untrodden paths of acoustical science. In this respect they resemble the old violin-makers of Italy, who also took a pardonable pride in their productions, which are the result of similar prolonged strivings.

The violin and the piano-forte, however, although in some respects similar, are in others widely different. The violin is endowed with perpetual youth. It even improves with age. The piano-forte does not. The violin is a mere shell of wood, modeled somewhat after a human shape, held together by glue, and strung with catgut; and although its various parts must be adjusted with great discrimination, and the bow with which it is excited be finely formed (having, for instance, a length of say twenty-nine and a quarter inches; weight of 900 grains; a diameter gradually decreasing, for twenty-three inches, from one-third to one-tenth of an inch, the curvature meanwhile increasing at an accelerating rate, to give a spring to the bow), yet this musical instrument, when compared with a piano-forte, appears as an extremely simple organism. It is more homogeneous, like all the other members of the numerous family of viols. The piano-forte, on the contrary, with its many kinds of wood, hard and soft, heavy and light; its many kinds of cloths and felts; of skins; with its masses of wrought and cast iron, steel, copper, brass, silver, lead, etc., is a more highly-complex production. It is heterogeneous, rather than homogeneous; and only by the most perfect coördination of all its parts does it retain an organization capable or worthy of preservation.

The piano-fortes of Erard, so highly prized for their extreme refinement and susceptibility to slightest variations of touch, are extremely delicate; and while other Europeans have succeeded in making more robust instruments, it has been reserved for the Americans the ability to endow their productions with constitutions capable of resisting, to any remarkable extent, climatal influences. The degree of their success, with reference to longevity, is not yet fully proved; and the variations in this respect are so great that it would be even rash to form an estimate, as we shall presently see. It is only safe to say that a piano-forte is never better than when it first leaves the hands of its maker. Like a young, impressionable being, it may then be made to suit special tastes and requirements. The readiness and extent of response to touch can then be determined, and the tones

may at once be made fuller, rounder, sweeter, harder, more brilliant and penetrating, or more sympathetic. It is vain to hope that they will be mellowed or otherwise improved with age or use.

For it is a common experience that piano-fortes differ greatly in the ability to retain their good qualities, even though subjected to the same conditions. It is also noteworthy that, although many instruments may be made precisely similar, and by the same workmen at the same season of the year, all other known things being also equal, they will differ in their characteristics, as children of the same family mysteriously differ from one another, although retaining many marked points of resemblance. It should, therefore, not cause surprise that among the 30,000 piano-fortes annually produced in the States some will be found so admirably balanced, so happily constituted, and adapted to endure great "wear and tear," as to survive mutilation, railway-accidents, extremes of heat and cold, dampness and dryness, and yet remain surprisingly vigorous and strong. Engineers and others acquainted with the conduct of iron—in suspension-bridges, for instance—which does not uniformly granulate, will not be surprised to learn that three strings struck uniformly with the same hammer may break at widely different periods, after losing their tenacity from the insidious nature of vibrations, and then from thermal changes rather than blows. But here we are not merely speaking of the strings, but of the piano-forte in its entirety—as consisting of a great number of mutually-depending parts, coöperating to a common end and the harmonious working of all.

To trace the gradual development of the piano-forte, from all its various archetypes, would occupy too much space. It is sufficient here to point out that virginals, spinets, clavichords, harpsichords, and various new forms of old types of similar instruments, were found incapable of further improvement. In the "struggle for existence" they failed to compete with the piano-forte, which, although at first far inferior, has finally survived them all. During the past fifty years, modern science has materially aided in enlarging its powers, especially in America; and it now claims our attention as the ultimate result of a long series of modifications superimposed on modifications which have led to what Mr. Herbert Spencer might designate as "an immense increase in the harmony between the organism and its environment."

European piano-fortes introduced by the early settlers here soon became useless. The dry land-winds of the interior, the moist sea-breezes of the coasts, the violent and sudden thermal changes, could not be endured. A new species had to be produced, for this one failed to become acclimated. The problem to be solved in those days was by no means an easy one. It was as difficult to improve upon the then existing piano-forte as it is to increase the capabilities of those we possess now. But the indomitable perseverance of sturdy souls

led them to face the difficulties resolutely, and devise "new internal relations" to meet "new external relations;" to bring about, as it were, a closer "correspondence between the organization and its environment." They learned that the "degree of life varied with the degree of correspondence;" that along with complexity of organization there goes an increase in the number, in the range, in the specialty, in the complexity of "adjustments of inner relations to outer relations," in what may perhaps be termed "the evolution of the piano-forte."

Their first, rather uncouth-looking instruments, with enormously large, solid wooden frames, appeared as an "unmixed breed," and therefore so far stable. They did not succumb so readily to the climate, and even presented peculiarities that attracted attention in Europe. The native woods of which they were made were found to be better adapted to the climate; polish was used even for the sound-boards, in preference to varnish, which evaporated, and other slight changes were adopted with great benefit. Yet still the requisite degree of strength could not be obtained from wood alone, and the comfortable classes using pile carpets, heavy curtains, soft cushions, and other warmth-retaining substances in their drawing-rooms, demanded a piano-forte that could make itself heard in the presence of so many deadeners of sound. Iron was then employed in combination with wood, but, the action of the two materials being by no means uniform under constantly-changing conditions, the desired equilibrium was not gained. In some instances the transverse swelling of the wood fractured the iron plates. Although this "mixed constitution" failed to meet the requirements then, the combination is now better understood.

The first intention of the application of iron—of the harp-shaped metallic ring—was not to enable the instrument to endure the constant strain of the strings. It was supposed that the metal would expand and contract uniformly with them, in the severe changes of this climate, and that in this manner the instrument would remain longer in tune, although the actual pitch might vary.

In 1837 the highly-skillful American maker, Mr. Jonas Chickering, conceived the bold idea of constructing a frame entirely of iron, and in the same year made his first square piano-forte in this way. In 1840 he produced the first grand piano-forte with an entire iron frame all in one casting. By this remarkable invention the piano-forte gained in truth an "iron constitution," competent to bear the atmospheric changes of this climate, and to it all subsequent successes are referred.

It was a great achievement to obtain a frame capable of resisting the enormous strain of the strings, but this advance imperatively led to innumerable variations being made in various details, for the attainment of an equilibrium, without which the promised gain could

not have been fully realized. The softer tissues still remained of wood of various kinds, and other such essential materials. With the acquisition of an iron frame or vertebra equal to the tensile strain of thirty tons without danger of fractures, came the temptation to employ strings of greater thickness, with a tension of from eleven to sixteen tons. These strings, stretched as near as possible to the limit of elasticity, that they might give forth the most vigorous vibrations, required to be set in motion by blows from hammers specially adapted for the purpose. (Voices similarly strained on the highest notes within their compass also have the most brilliant quality, as for instance the "G" of Mr. Santley and the chest "C" of Tamberlik.) Then, again, the increased powers of the instrument made greater demands on the sound-board.

If we compare the vibrations of the violin, set up by the comparatively gentle friction of the bow, with those of a piano-forte sound-board, violently trembling in response to strong percussive accents, and the multitudinous and continuous vibrations of long, thick metallic strings, it is at once evident that they are of a more extraordinary nature. Great discrimination was used in the selection of the wood from the spruce-trees of the Northern forests; many experiments were made to discover which way the grain of the wood should be disposed, and in what manner the sound-board should be compelled to receive and transmit impressions without fear of such derangements as should lead to a state of paralysis. To make it act most energetically the fibres were permanently compressed longitudinally, as in a vise, up to a certain point, similar to the strings, which, as we have just now seen, give forth tones of most satisfactory quality when stretched to the verge of breaking. There is a readily-found precise limit to this compression, after which the tones become hard and thin in quality. The sound-board is now also slightly curved, forced upward or made convex that it may resist the downward pressure of the bridge that holds the strings slightly elevated from their level, to secure a complete and intimate communion for the transmission of vibrations. It is clear that, if, from any cause, a sound-board should become concave, or loose at any of the sides, serious consequences would ensue. Considerations such as these sufficiently prove that the attainment of a perfect harmony among the parts, to resist successfully external influences, was no slight undertaking.

The American piano-forte has, however, attained a constitution that will endure dryness, cold, and even furnace-heat, but succumbs to excessive dampness. A good instrument, dried to the utmost, rapidly absorbs moisture. The well-fitted parts, having no room to swell, then become rigidly bound together, and thus the action is destroyed. It would therefore suffer if placed in a room having no sub-cellar, under which water-courses might be formed after rains. An inferior instrument made with damp materials and kept damp by

judicious sprinkling, ostensibly to allay dust, might thus successfully compete with a good instrument during an ordinary public exhibition, although it would soon prove worthless.

Varnish is now used for sound-boards and cases, both here and in England.

The constitution of the English piano-forte enables it to bear the English climate, in which the humidity is more uniform. When brought here it breaks down. But even the American piano-forte can only to a certain extent bear the trials from climatal changes to which it is subjected, and for a very limited space of time in some parts of the States, as, for instance, the Rocky Mountains. If a good instrument, made with native woods, seasoned for two years in the open air, and kiln-dried for three months at 130° Fahr., be removed in winter, while the thermometer is at zero, and placed in a heated concert-room, the sudden rise in the temperature, causing dampness, would affect the glue as well as the wood-work. But when organic derangements are not caused, a host of minor ailments set in which impair and gradually destroy a piano-forte. The metals corrode, the strings break, the pins holding the wires relax their hold, and then turn round (in inferior instruments), the felt on the hammers becomes worn, the damper actions rattle, the various centres loosen, the hammers (that deliver the blow before the key is fully down, and then immediately retire from the string, to allow it to vibrate and take up such a position as to deliver a number of consecutive blows with rapidity) may act with irregularity, or without the requisite vigor, and moths may attack the felt and cloth. Although many of such ailments yield to treatment, yet they are unmistakable signs of general decay. In forming an estimate, however, of the longevity of a piano-forte, one should reflect on his growing insusceptibility to sensuous impressions, and not institute comparisons with newer instruments of greatly-enhanced capabilities. It is well also to point out that sometimes articles of furniture, free to vibrate, will do so in sympathy with certain notes of the instrument, and thus make a supposed defect. Articles, such as a stiletto in a metal sheath, or a glass globe on a gasalier, are not readily detected in the act of responding.

On comparing piano-fortes by various makers it is well also to bear in mind the special peculiarities of each. The makers of the Erard piano desire to produce a brilliant, ringing effect, and do not destroy the numerous, tingling overtones which succeed the cessation of their primaries. Sensitive artists, who desire an achromatic quality, object to these, although they are intended to add a kind of harmonic halo or lustre to the general tone, which in a crowded drawing-room might appear dull and lifeless—wanting in radiance and animation. The Broadwood makers strive for the formation of a full, organ-like tone. The Collards are successful in obtaining flute-like and liquid tones, which in the treble are remarkably sweet and dulcet. The Ger-

man piano-fortes are generally rough and unfinished in mechanical details when compared with the French, although the tones are stronger.

Yet neither bear comparison with those of America. These also, among themselves, present marked characteristics. One maker prides himself on the magnitude and power of his instruments, and their fitness to be employed with the orchestra in large halls; another on the delicacy and extreme purity of the tone, which he deems can only be attained from instruments intended for the drawing-room or halls of moderate size; a third may try to obtain a "traveling-power," which quality is so markedly deficient in many upright pianos and in free-reed organs, as compared with grand piano-fortes and pipe-organs, that always sound better when at some distance. Great attention is always paid to the material and form of the hammer, which is found to produce the best tone when covered with soft felt, made of the wool of the merino sheep. This Saxony wool is worked here by Germans. Great care is also paid to the spinning of the covered wires, and the consistency of all the others to avoid defects that would lead to beats, and deceive the tuner.

Much experience and practical skill are required in the designing of the scales, or elaborate balancing of length, weight, thickness, material, and tension of the strings, to secure uniformity from bass to treble, while conforming to a given length of case, although the design may be planned in accordance with the mathematical theories of stretched strings. Then, again, the point where the blow is to be delivered is carefully chosen, that objectionable nodes may be destroyed. For the same reason wedge-like dampers are employed to check vibrations, and are made to act at a point where subsequent dissonant overtones may be rendered impossible. For the want of this last precaution, an otherwise valuable upright piano-forte, by a prominent firm in Germany, was pronounced a failure in London, some years ago. On striking any one of the bass notes, and then raising the key, after a short interval of silence, the harmonic seventh was generated; and this was no weak, vanishing tone, but a strong, continuous sound resembling that of a musical glass.

On studying the detailed accounts of new patents for improvements—real or imaginary—on comparing the statements of rival makers, or on being persistently contradicted by interested experts, one learns the difficulty of forming an opinion on points at issue, having reference to the advantages gained by alterations in the mode of constructing piano-fortes. It demands considerable special knowledge even to fully comprehend these points. One should carefully avoid expressing opinions that might tend to affect values, and be content with the reflection that the public at large is well enough informed to know that only those firms possessing the requisite capital, intelligence, and experience, can produce an intrinsically valuable instrument.

Cheaply-made piano-fortes are mostly sold to ignorant persons, living far from the great centres of civilization.

It will be found interesting to notice some of the facts learned by those who have conducted experiments in the hope of improving the piano-forte, for many of these are somewhat peculiar, and contrary to general anticipation. Thus: Chladni's figures are not formed by sand strewed on the sounding-board; nor does the sand travel from the point where the shocks or impulses are imparted to this vibrating body, but collects at this very point, namely, close to the bridge. Again, no difficulty is experienced by "interference," when two or three strings tuned in perfect unison vibrate side by side; nor from overstringing the bass wires. The fitting together of trough and crest of sound-waves—the coincidence of the "swing" and the "swang," which cancels both, and forms the hyperbolic curve of silence on the outer broad side of each prong of a tuning-fork, is a phenomenon that does not appear in any portion of the scale. Nor does that which is termed "sympathy," that occurs when two organ-pipes stand too near each other, require consideration from the designer of a piano-forte. The addition of a second string, far from destroying the vibrations of the first, or even interfering with them, more than doubles the power of the tone. A single string gives forth a comparatively insignificant and feeble note. When three strings are used, the third does not add half as much again, a fourth string adds still less in proportion, and, judging from the quality of the tone produced, seems to require an entirely new design.

In the final adjustments of the piano-forte by men of extremely keen sensibilities, certain defects, limitations, and peculiarities of the human ear, have been discovered that are noteworthy. The Greek architects well knew that long horizontal lines, if straight, would not appear to be straight when viewed from below, and therefore in the Parthenon they executed exceedingly delicate curves. Their columns were not exactly cylindrical, and many similar and most subtile deviations from geometrical truth were employed that remain as evidences of their consummate skill. In music, also, certain *nuances*—deviations from rigid accuracy or mathematical truth—are constantly made by which the powers of true artists are manifested. These minute shades of difference—these slight variations or modifications of quality of tone, power of tone, pitch, speed, etc.—when not exaggerated, but determined with an art-concealing art, are found to be true to Nature, and find their justification, not as exceptions to general rules, but as exemplifications of the highest principles. The refined perceptions of piano-forte finishers have led them to the fact that the highest notes of the instrument should be tuned slightly sharper than perfect, or each note will appear to be flat, when compared with the octave below. If these notes are tuned perfectly, and proved to be so by various tests, there still remain a secret dissatisfaction and conscious-

ness of a certain dullness, which detracts so much from the good effect of the instrument as to lead some persons to suppose it to be one of inferior quality. The expedient, therefore, of slightly raising the pitch of about seventeen of the highest notes (when the piano-forte is extended to high C) is adopted, by which the instruments gain greatly in brilliancy, briskness, sprightliness, or whatever term may fitly denote the reverse of flatness and insipidity. Octaves tuned in the middle of the key-board are frequently deemed perfect when too small, and some few students of tuning are prone to accept as true, octaves that are too large in this region of the scale.

But by far the most extraordinary fact, with reference to the final adjustment of the piano-forte, is the general acceptation of its particular "temperament" for all instruments having twelve notes to each octave. Whatever other temperament may be chosen for such instruments, only one simple, natural diatonic scale can be properly rendered. With this arrangement, called the "equal temperament," not a single chord is correctly tuned. No intervals are made absolutely perfect, but the ear has gradually been led to be content with them, when they approximate the truth in conformity with this particular system. By the equal distribution of the many kinds of *apotomes*, found on calculating intervals from the scale given by Nature's super-harmonics, they are subsequently practically disregarded—treated as non-existent—and thus elaborate modulatory harmonies are rendered comparatively easy to construct; and the human ear being less able to detect imperfections in dissonances than in consonances, composers have gradually employed, with increasing freedom, dissonances of the most unusual and startling kind. It would not be strictly true to say that modern writers have neglected the sweet, cloying style—abounding in pleasant-sounding phrases—because the absolute perfection of these ready-made, dissonant harmonies is more readily overlooked. The influences that have determined the course of modern art can only be perceived from a psychologic point of view. We may, however, safely say that modern composers have not been deterred, but rather assisted, if not actually emboldened, by their enharmonic intervals being made freely interchangeable, their far-fetched harmonies easily found and little scrutinized; and point out that the dynamic power of discords increases their present value as artistic materials, now that fugal and similar forms, compelling progress, are more rarely used.

The temperament of the piano-forte led directly to the entire remodeling of the "king of instruments," the church-organ; but yet, not without considerable strife. During the first three-quarters of the present century this particular form of temperament was a matter that greatly exercised mathematicians, organ-builders, musical purists, clergymen, and organists, in England, and has only now become generally adopted in that country. The solid and highly-com-

pound tones of the organ, sustained with equal energy, caused the imperfections of the concords to be markedly apparent. They could not be ignored, as when occurring with the evanescent tone of a piano-forte. The super-harmonics, or summation-tones, disagreeing with each other, developed, in common with difference-tones, a mass of attendant dissonances, which even the employment of a double foundation (sixteen-feet manual stops) and powerful pedal-organ, etc., could barely hide.

The music of the Church was then as calm and free from passion as the sculptures of Phidias; no exciting dissonances held the listener spellbound until they were resolved. The organ-builders, accordingly, produced instruments that were solemn, sedate, serious and grave, forcible and powerful, without betraying passion or the flutterings of private, personal emotion. To use this temperament would be to destroy these features, which the piano-forte-makers did not desire to retain. They sought brilliancy and contrast for secular requirements, and were at once manifestly gainers by the system; while the organ-builders were compelled to reflect very seriously on matters of ritual and their own reputations.

To make this clear: Let the length of a stretched string be represented by unity, and $\frac{1}{2}$ or $\frac{64}{128}$ the octave. Now, three major-thirds are less than an octave; for $\frac{4}{5} \times \frac{4}{5} \times \frac{4}{5} = \frac{64}{125}$. Again, let $\frac{1}{2}$ or $\frac{648}{1296}$ represent the octave, and it will be seen that four minor-thirds are greater than an octave; for $\frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} = \frac{625}{1296}$.

The contraction of the minor-thirds, therefore, by one-fourth of the ratio 625 to 648, caused a further depression of the significant note in the minor-chord, by which it became more gloomy and depressed; and the expansion of the eloquent major-third by one-third of the diesis, or ratio of 125 to 128, caused the expression of joy in the major-chord to be exaggerated or intensified, or even over-excited, when compared with the peaceful, contented, restful character of the pure harmony.

These violent contrasts affected the quality of the tones, not individually, but when heard in combination. The general character of the tone-tint was thus greatly modified.

That the ear is much more sensitive to imperfections of intervals with simpler ratios is proved by the uneasiness experienced while a violinist tunes his strings to the interval of a fifth ($\frac{2}{3}$). Twelve such fifths exceed the octave by an interval having the ratio of 524.288 to 531.444. Each successive fifth must, therefore, be contracted one-twelfth of this interval (or *diaschisma*), that the series may be bounded by a perfect octave; and in this manner the tonal system of keys, which is in reality a slowly-ascending infinite spiral, practically takes the form of a circle. This fact must be borne in mind if one would satisfactorily account for many laws of art. The ideal purity which enraptures the creative artist is never realized; for all performances are marked by the imperfections attending human efforts.

That a general compromise, or sacrifice of truth to convenience, must be made in instruments having twelve fixed tones to the octave, will be seen by a comparison of three most closely-related diatonic scales, and their respective proportions:

								G.	A.	B.	C.	D.	E.	F-sharp.	G.
								240	$213\frac{1}{3}$	192	180	160	144	128	120
				C.	D.	E.	F.	G.	A.	B.	C.	D.	E.	F.	G.
				360	320	288	270	240	216	192	180	160	144	135	120
F.	G.	A.	B-flat.	C.	D.	E.	F.	G.	A.	B-flat.	C.	D.	E.	F.	G.
540	480	432	405	360	324	288	270	240	216	$202\frac{1}{2}$	180	162	144	135	120

It is clear to the meanest comprehension that the sound "D," the second note of the scale of "C," differs from "D," the sixth note of the scale of "F;" and also that the sound "A," the sixth note of the scale of "C," differs from "A," the second sound of the scale of "G;" and similarly, in the ratio of 80 to 81.[1] It is evident that any

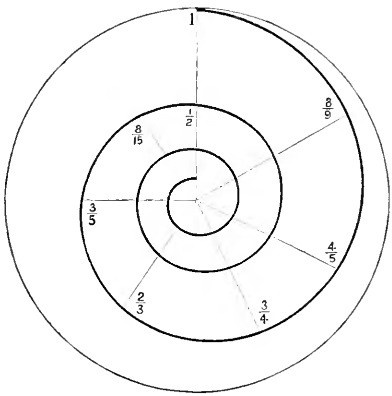
[1] The relative speeds of the vibrations of each note of the diatonic scale are here given for the convenience of persons accustomed to calculate by their aid.

264 297 330 352 396 440 495 528

The true diatonic scale may be represented in various ways, which may occasionally prove useful in measuring intervals, although the divisions are not exactly correct. Such as—

ASCENDING SCALE.	1. The Periphery of a Circle.	2. 53 Degrees.	3. 301 Degrees.	4. 730 Degrees.	5. In Mean Semitones.
C.	33° 31″ 11′	10	56	136	1.1173
B.	61 10 22	27	153	372	2.0391
A.	54 43 16	16	92	222	1.8240
G.	61 10 11	27	153	372	2.0391
F.	33 31 11	10	56	136	1.1173
E.	54 43 16	16	92	222	1.8240
D.	61 10 22	27	153	372	2.0391
C.	. . . .	. .	. . .	. . .	. . . .
	360° 0″ 0′	53	301	730	12.0000

But the logarithms of the ratios of the intervals are most generally used. The logarithmic or equiangular spiral best illustrates to the eye the return of the octave, the curve



being so drawn that a complete revolution halves the distance from the pole. It is also valuable for other properties besides this geometric periodicity, representing a continuously-rising tone.

note, say "D" on the piano-forte, which has to do duty for all the various kinds of "D," as well as those of "C double-sharp" and "E double-flat," must be so attuned as to form a happy mean between them.

If, then, in the extremely simple case given above, drawn from the triune system of scales and chords, exemplified in the most insignificant compositions, one may be led to doubt and difficulty, it is easy to understand that violinists and others prefer to follow blind rules, leading them to make, for instance, all notes with sharps, higher than their enharmonic equivalents in flats, and *vice versa*, in elaborate compositions, that would involve calculations of extreme complexity; or, in such cases, to follow their own subjective feelings rather than seek justification by mathematical proofs, especially when performing alone their own parts, and thus not called upon to act in conformity with others. In such cases, notes depressed, and having a downward tendency, are more depressed; and notes raised, which are aspiring, are made more elevated. The interval C : G flat would therefore be contracted, and that of C : F sharp enlarged in the following (frequently-heard) expressions:

G-flat........F.		F-sharp.........G.
C............D-flat	and	C..............B.

The "C" in the first progression is also virtually a raised note, and the "C" in the second a depressed note, as may be seen by reference to the scales indicated by the terminating chords. The laws which musicians obey, consciously or unconsciously, in the ordinary routine of composition and performance, are very fascinating, and will ere long be systematized.

The three scales given above prove that the chord of A-minor, formed with two notes from the chord of C, differs in altitude from the chord of A-minor formed from the chord of the parallel A-major, by depressing the third; and also that the minor-third from the second to the fourth note of a scale is smaller than the remaining minor-thirds. These facts seem to have escaped the attention of all writers on harmony, who bewilder students with elaborate arguments respecting the so-called "chord of the added sixth," that undermine their own theories.

Having now drawn attention to the use of the piano-forte, its evolution, longevity, ailments, etc., and compared it with the violin with reference to its vitality; having also shown some of the singular facts that are the common experience of piano-forte makers and tuners respecting the human ear, and the system of temperament, which has not been a hinderance to the course of modern art—let us now consider that remarkable phenomenon, the "peculiarity of the key," which remains, or is acknowledged to remain, by most candid persons, even now that equal temperament is universal, and that the pitch has been gradually raised.

In the English translation of Bombet's "Life of Haydn" a list of the keys is given with their acknowledged characteristics appended. Thus: "D-flat major. Awfully dark. In this remote key Haydn and Beethoven have written their sublimest thoughts. They never enter it but for tragic purposes." Again · "A-flat major. The most lovely of the tribe. Unassuming, gentle, soft, delicate, and tender, having none of the pertness of A in sharps. Every author has been sensible of the charm of this key, and has reserved it for the expression of his most refined sentiments." And so on. Now, it was never supposed that the peculiarities of the keys could be confused with the peculiarities of the old modes, such as Dorian, Phrygian, etc., which led Dryden to say, "Softly sweet in Lydian measure;" for all these modes were designedly, mathematically, and markedly, dissimilar. But it was generally supposed that the "unequal temperament," which favored some keys at the expense of others, led to the various, otherwise unaccountable, characteristics. These, however, have remained, singularly enough, with the "equal temperament," by which system all the keys are equal—i. e., the ratios of their intervals are precisely similar.

This peculiarity of the key is not to be confounded with other, accountable differences: such as induce composers to write in flat keys for military bands to attain the greatest brilliancy, and in sharp keys for orchestras for the same end. In these cases the greater number of open notes (more naturally and simply formed tones), and other such known facts, lead to a clear understanding on this point. But in the piano-forte no such considerations can be made to account for the subtile phenomenon. It was once supposed that the absolute pitch employed was the cause of the difference; but since the time of Haydn the pitch in all countries has risen to such an extent that the scale of A-flat characterized above has become virtually the scale of A-natural, with which it was there compared; but no corresponding variation of opinion respecting it has been recorded. Ladies still commonly express a decided preference for flat keys, and probably for this reason fashionable drawing-room music is generally cast in four or five flats—although these keys may be also chosen partly because, according to the conformation of the hand and the disposition of the ivory keys, the chords with flats are more easily and readily controlled, especially when distributed in the arpeggio style, and have to be played with great speed, freedom, and facility. But the various attempts made to account satisfactorily for key-character on the piano-forte have hitherto only demonstrated that reason and understanding are incapable of fathoming and explaining the matter.

The piano-forte of the present day is, as we have seen, the result of many contributions. Posterity alone can pronounce judgment upon it, and show in what it is deficient; for who shall say what the "piano-

forte of the future" will be? We ourselves complacently regard our age and its works, while anticipating the constant progress of the human race and its increasing ability to "reveal itself in tones."

SNORING, AND HOW TO STOP IT.

By JOHN A. WYETH, M. D.

TO those unacquainted with the mysterious parlance of the anatomist, the use of strictly scientific terms might prove discouraging and fail to interest. I shall therefore discard the *scientific* in favor of the *every-day* phrases, in explanation of the following figure (1), which, it will be observed, represents a human head split from above downward through the central line.

Through the only two channels in which the air travels in going to the lungs, namely, through the nose and mouth, are drawn two arrows,

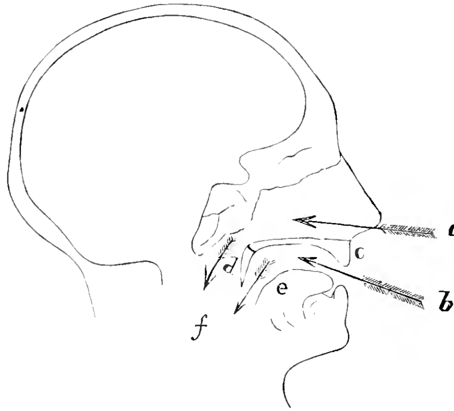


Fig. 1.

a and *b*. These two passages unite in a common cavity at *f*, and from that point there is but one tube leading to the lungs.

At *c* is a bone called the *hard palate*, which forms the roof of the mouth and the floor of the nose, separating these two air-channels from each other. At the inner or posterior end of the bone, *c*, is seen a little body, *d*, called the *soft palate*, made of muscle and covered with a delicate skin. This *soft palate* is attached at one end to *c*, the *hard palate*; the other end hangs loose, and moves or flaps in the act of breathing, something like a window-curtain when acted upon by a current of air. This is its condition while we are asleep or awake, though during sleep it lacks in *tonicity*, being much more relaxed, or flabby, than when we are awake. At *e* is represented the tongue.

Now, in order to snore, one must keep the mouth open, as well as the nose, and in this condition the two currents of air, *a* and *b*, passing in and out together during the acts of breathing, catch this little curtain, *d*, between them, and throw it into rapid vibration. This vibration, more or less intense and sonorous, is what we call *snoring*.

It is only with the mouth open that snoring can be accomplished during sleep. Awake, if the nose is closed by the thumb and finger, by taking a forcible breath, it is possible to snore, and the same result may be accomplished with the mouth shut and the nose open; but the muscular effort necessary to its accomplishment is more than we can command during sleep, and would wake up the individual who might unconsciously make the effort.

If the mouth be closed (the natural condition during slumber), but one current of air will pass to and from the lungs. This current, pressing about equally upon all sides of the canal indicated at *a*, will press the *soft palate*, *d*, forward and downward until it is applied to the tongue, *e*, and will hold it there gently, thus preventing any sonorous vibration.

It follows that any device which prevents the lower jaw from dropping down, during the relaxation of sleep, and opening the mouth, will shut out the one unnatural current of air and prevent snoring.

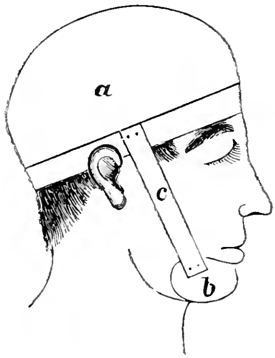


Fig. 2.

I have devised the apparatus represented in Fig. 2, which consists of a simple cap, *a*, fitting the head snugly; a cap of soft material, *b*, fitting the chin; and a piece of elastic webbing, *c*, tacked to the chin-piece, and to the head-cap near the ears. The webbing can be made more or less tense as may be required to effect the closure of the mouth.

The apparatus is so simple that any one can make it; and the writer hopes this explanation will recommend itself to those individuals who, from the possession of this unfortunate habit, are a nuisance to everybody—excepting themselves.

MARS AND ITS SATELLITES.

By Professor DANIEL KIRKWOOD.

THE recent and wholly unexpected discovery of two Martial satellites has awakened a new and lively interest in all that relates to our neighboring planet. Its telescopic aspect and the probable nature of its physical constitution are especially worthy of renewed consideration.

The mean distance of Mars from the sun is 139,877,000 miles.[1] Its orbit deviates more from the circular form than that of any other principal planet with the exception of Mercury; its eccentricity being 0.09326. The difference, therefore, between its greatest and least distance amounts to about 27,000,000 miles. But the eccentricity, though great, is nevertheless increasing; and, when it shall have attained its superior limit, the aphelion distance will be 196,000,000 miles. This is greater than the perihelion distance of many asteroids. Mars, therefore, occasionally invades the cluster of minor planets. Is it not possible that his superior force may attach some of its members to his retinue of satellites?

Mars was the first planet to exhibit indications of an axial revolution. As early as 1636 Fontana, a Neapolitan astronomer, had an imperfect view of a spot on the planet's disk. He reobserved the same figure in 1638, and from the changes noticed in its position and aspect he inferred the probability of the planet's rotation. He seems, however, to have made no effort to determine its period. Dr. Hooke, in 1666, noticed some well-defined spots, which he found to change their appearance on the surface, to disappear and return at regular intervals; whence he inferred that the planet completes a rotation either in twelve or twenty-four hours. During the same year Cassini observed spots on each hemisphere of the planet, from the motions of which he concluded the period of rotation to be $24^h\ 40^m$. In 1704 Maraldi, the nephew and pupil of Cassini, made a series of observations on the spots, from which he deduced a period of $24^h\ 39^m$. In 1719 he renewed his observations under favorable circumstances, and obtained a period precisely equal to that originally found by Cassini. In order to determine the exact period of rotation, Sir William Herschel undertook a series of observations in 1777, which he again resumed in 1779. From the changes which he observed in the appearances of the planet he fixed the time of revolution at $24^h\ 39^m\ 21.67^s$. The determination by Kunowsky in 1821 gave $24^h\ 36^m\ 40^s$. The observations of Beer and Mädler in 1830 indicated a period of $24^h\ 37^m\ 10^s$. Their observations, however, in 1832, combined with

[1] This value corresponds to a solar parallax of 8.88″.

those of 1830, gave $24^h\ 37^m\ 23.7^s$. In regard to the exact period of rotation and the slight discrepancies between the results obtained by different observers, Prof. O. M. Mitchel remarks as follows:

"In 1839 Mädler reviewed Herschel's observations, whence his first results were deduced, and discovered that, after introducing the necessary reductions, the discrepancy of two minutes might be reduced to two seconds, by giving to Mars one more rotation on its axis, between the observations of 1777 and 1779, than Herschel had employed.

"By combining Mädler's observation, made at Berlin, 1830, September 14th, $12^h\ 30^m$, with one made at the Cincinnati Observatory, 1845, August 30th, $8^h\ 55^m$, making the corrections due to geocentric longitude, phase, and aberration, I find the period of rotation to be $24^h\ 37^m\ 20.6^s$, differing by only two seconds from Mädler's period as last corrected."[1]

Finally, Richard A. Proctor, Esq., by an exhaustive discussion of all the observations, has determined the period to be $24^h\ 37^m\ 22.735^s$.

The diameter of Mars is about 4,700 miles. Its surface is rather more than one-third that of the earth, while its volume is to that of our planet in the ratio of two to nine.

The persevering labors of Beer and Mädler proved beyond question that many of the lineaments observed in the aspect of this planet are permanent in their character, and not merely atmospheric. The same spots, with the same general outlines, and the same varieties of color, have been noticed at successive oppositions; not always, it is true, with precisely the same distinctness, but without any other changes than such as might be attributed to atmospheric variations. Two white circular spots are observed in the polar regions, which *increase* during the winter, and *decrease* in the summer, of each hemisphere respectively, and which may, therefore, be regarded as polar snows. These spots were noticed by Maraldi as early as 1716; their connection, however, with the change of seasons was first shown by Sir William Herschel. The same astronomer found the inclination of the axis of Mars to the plane of its orbit to be 61° 18′. The Martial tropics are therefore 28° 42′ from the equator, making the torrid zone 10° wider than that of the earth. In so far, then, as climatic changes are dependent on the obliquity of the planets, the seasons of Mars may not differ, perhaps, except in their duration, very greatly from our own.

THE SATELLITES OF MARS.—We come now to the history of one of the most interesting discoveries of the nineteenth century. With the single exception of our own moon, Mars is the most favorably situated of all the heavenly bodies for telescopic observation. The most careful scrutiny, however, for more than two centuries, had failed to furnish any indication of the existence of a satellite. The opposition of Mars in August, 1877, occurred when the planet was

[1] *Sidereal Messenger*, p. 101.

very near its perihelion. The body was, therefore, in the best possible position for close examination. At the approach of this favorable epoch the new twenty-six inch refractor of the Naval Observatory at Washington, under the skillful direction of Prof. Asaph Hall, was turned upon the planet. On the night of August 11th a small star was observed near the disk of Mars, but its true character was not then suspected, or at least not determined. On Thursday night, the 16th, at $11^{h.} 42^{m.}$, Prof. Hall again noticed a star of the thirteenth or fourteenth magnitude, very close to Mars, and measured its apparent distance from the planet. On the same night, about two o'clock, he again examined the planet, and to his great surprise found that the small star had moved in company with Mars. *He had therefore discovered a Martial satellite.* On Friday morning the observations were submitted to Prof. Simon Newcomb, who, from the data furnished by a watch of five hours, calculated the time of revolution, which he fixed as a first approximation at 31 or 32 hours. This showed that the satellite must pass behind Mars some time during the following night. It was accordingly invisible when first looked for in the evening, but, as predicted by Newcomb, it reappeared about one o'clock. On Saturday morning the discovery was made known to Admiral Rodgers, the superintendent of the observatory. It was determined, however, to wait for another observation before formally announcing so important a discovery. On Saturday evening the satellite was again found very nearly in its predicted place, and its exact position was measured by several astronomers.

About four o'clock on the morning of August 18th Prof. Hall discovered a second satellite, interior to the orbit of the first, and of about the same apparent magnitude. The astronomers of Europe were officially notified of the facts by the following dispatch:

"WASHINGTON, *August* 18, 1877.

Two satellites of Mars have been discovered by Hall at Washington. First, elongation west, August 18th, eleven hours, Washington time. Distance, eighty seconds; period, thirty hours. Distance of second, fifty seconds.

"JOSEPH HENRY."

The statement of fifty seconds as the distance of the inner satellite was subsequently found to be quite erroneous.

On Monday, August 21st, Rear-Admiral Rodgers, superintendent of the observatory, communicated the discovery, together with Prof. Newcomb's approximate circular elements of the orbits, to the Hon. R. W. Thompson, Secretary of the Navy.

DISTANCES FROM THE CENTRE OF MARS.—The distance of the inner satellite from the centre of the primary is about 5,700 miles; that of the outer, 14,200. The distance of the former from the surface of Mars is but 3,300 miles—no greater, in fact, than that of London from New York. The apparent magnitude of Mars as seen from this satel-

lite is 2,000 times greater than that of the sun or moon as seen from the earth.

Periods of the Satellites.—Prof. Newcomb gives 30^h and 14^m as the period of the outer satellite, and 7^h and 38^m as that of the inner. Both move, like our moon, from west to east. The period of the inner is *less*, while that of the outer is *greater*, than a Martial day. It is obvious, therefore, that, as seen from the surface of the planet, the *apparent* motion of the satellites will be in opposite directions, the inner rising in the west and setting in the east; the outer rising in the east and setting in the west—so that the phenomenon of two moons meeting in mid-heaven will be to the Martialists no unusual occurrence.

The Mass of Mars.—Before the discovery of these satellites the determination of the mass of Mars was a problem of great difficulty, the body being too small to have much effect in disturbing the motions of other planets. The value assigned by Burckhardt was $\frac{1}{2680337}$, that of the sun being unity. The difficulty of the problem is now happily removed, and Newcomb has found from the elements of the exterior satellite a value of $\frac{1}{3090000}$; a mass less than Burckhardt's in the ratio of six to seven.

The Bearing of the Discovery on the Nebular Hypothesis.—The inner satellite of Mars completes three orbital revolutions in less than a Martial day. This anomalous fact in the planetary system would seem, at first view, to be utterly inconsistent with the nebular hypothesis. The question is one of more than ordinary interest, but its discussion may well be deferred until we shall have obtained more exact information in regard to the Martial system.

HUXLEY'S AMERICAN LECTURES.

By Professor E. RAY LANKESTER.

THE five addresses which have been recently brought out by Prof. Huxley in the form of a small volume were delivered under very varied conditions, and deal with subjects widely separate from one another. Three of them form a series of lectures on the doctrine of Evolution, and were delivered by the author at New York in September, last year. These were the only popular scientific lectures which Prof. Huxley would allow himself to undertake during his summer holiday devoted to a tour in the United States. The "Address on University Education" was delivered at the formal opening of the Johns Hopkins University, at Baltimore, during the same visit. The concluding lecture of the present volume was delivered in connection

with the Loan Collection of Scientific Apparatus at South Kensington in December, last year, and deals with the study of Biology.

The range of topics thus indicated is wide enough to give us samples of all the moods of Prof. Huxley's vigorous and eloquent style. As compared with his previously-published addresses and essays, we find no diminution of power, no less artistic care in the arrangement of materials, no less cogency of argument and stern insistence on the appeal to facts rather than to *a priori* considerations, nor can we detect any indication that as he grows older the author is more timid in face of those "logical consequences" of his teaching—the bugbears of some, but the beacons of other, philosophers. Perhaps—and this is more especially noticeable in the lectures on Evolution—there is less of that playful treatment of opponents and their transgressions—that sudden but graceful discomfiture of his adversary by the unexpected production of a quaint though close-fitting illustration—which in former writings gave a pungency and aroma to Prof. Huxley's pages no less fascinating than peculiarly their own.

In the three lectures on Evolution, the history of Nature is made the subject of a closely-reasoned inquiry. Three current hypotheses—the Uniformitarian, the Miltonic, and the Evolutional—are recognized, and their respective claims to our acceptance discussed. The paleontological evidence in favor of the hypothesis of Evolution forms the subject of the second and third lectures, and with great skill the opportunity is used in order to bring before an American audience in the most forcible way two very important and interesting American discoveries of recent date. America is, indeed, rapidly becoming the headquarters of paleontological research. Prof. Huxley's own discoveries regarding the genealogical connection of birds and reptiles form an important argument in favor of the hypothesis of Evolution, and in placing this argument before his audience he was able to explain to them at some length the interesting new fossil birds obtained by Prof. Marsh, of Yale College, from the cretaceous rocks of Western America. The structure of two of these birds, *Hesperornis* and *Icthyornis*, which possessed, unlike all other birds, distinct conical teeth imbedded in their jaws, is illustrated by woodcuts in the printed lecture. Now that the principle has been admitted, we may hope to see an illustrated edition of some of the lectures which were issued in preceding volumes without woodcuts.

The second American discovery which is brought to bear on the hypothesis of Evolution, and forms, indeed, part of what Prof. Huxley calls the "demonstrative evidence of Evolution," relates to the pedigree of the horse, and is also due to Prof. Marsh. Strangely enough, America, which within the historic period is remarkable for the absence of indigenous horses, and the fertility within her borders of the wild-horses descended from domesticated ancestors of the Old World, is even more remarkable for having buried in her soil a greater

number and variety of fossil horses than any that the Old World can show. *Eohippus* and *Orohippus* from the American Eocene deposits, and *Mesohippus* from the American Miocene deposits, are most important links in the series (the later members of which are *Pliohippus*, *Hipparion*, and *Anchitherium*, found also in European Tertiary strata), connecting the living one-toed genus Equus with a typically five-toed ancestor common to it and other ungulate mammals. The structure of the feet and teeth of this series of forms, which furnish demonstrative evidence of the evolution of the horse by progressive modification, is placed before the reader in its main features with great clearness, and the description is notably assisted by a full-page woodcut.

The choice of the term "Miltonic" in place of any other for what is sometimes termed the "Mosaic" account or hypothesis of creation, and the statement of the reasons which have led to that choice, are samples of a kind of serious jesting in which Prof. Huxley shows infinite skill and delicacy. There is no doubt, he urges, as to Milton's view of the history of creation, as given in his great poem. On the other hand, were a writer to call this the "Biblical doctrine," he "would be met by the authority of many eminent scholars, to say nothing of men of science, who at various times have absolutely denied that any such doctrine is to be found in Genesis." In fact, we are told by these authorities that the six days of Genesis are six periods that we may make just as long or as short as convenience requires. "A person," says Prof. Huxley, "who is not a Hebrew scholar can only stand aside and admire the marvelous flexibility of a language which admits of such diverse interpretations." The term "Mosaic," in reference to the same doctrine, Prof. Huxley also considers objectionable, because "we are now assured upon the authority of the highest critics, and even of dignitaries of the Church, that there is no evidence that Moses wrote the book of Genesis, or knew anything about it."

"You will understand," he says, "that I give no judgment—it would be an impertinence upon my part to volunteer even a suggestion—upon such a subject. But that being the state of opinion among scholars and the clergy, it is well for the unlearned in Hebrew lore, and for the laity, to avoid entangling themselves in such a vexed question. Happily, Milton leaves us no excuse for doubting what he means, and I shall therefore be safe in speaking of the opinion in question as the Miltonic hypothesis."

The Baltimore address gives us a sketch of the writer's ideal of primary education, of university education, and especially of medical education—how to encourage research, and how best to fill vacancies in a professoriate. He does *not* hold the view that "you can go into the market and buy research, and that supply will follow demand, as in the ordinary course of commerce." His conviction is that "the best investigators are usually those who have also the responsibilities of instruction." Very valuable for other universities than that of

Baltimore are Prof. Huxley's few words of advice on "buildings." "Get an honest bricklayer, and make him build you just such rooms as you really want, leaving ample space for extension." When

"you have endowed all the professors you need, and built all the laboratories that are wanted, and have the best museum and the finest library that can be imagined; then, if you have a few hundred thousand dollars you don't know what to do with, send for an architect, and tell him to put up a façade. If American is similar to English experience, any other course will probably lead you into having some stately structure, good for your architect's fame, but not in the least what you want."

The South Kensington lecture contains some strong pleading for the study of Biology, as a subject of deep importance to the community. Among other illustrations of its importance it is urged that thereby alone are men able to form something like a rational conception of what constitutes valuable criticism of the teachings of biologists. "Brilliant articles" are from time to time written by "paper-philosophers" devoid of even the elements of biological knowledge, and the teachings of biologists are demolished, while the weathercock heads among us are, Prof. Huxley tells us, much exercised by the "winds of doctrine" let loose in the said articles. Turning, however, to his favorite storehouse of metaphor, he finds that the brilliancy of the writers "is like the light given out by the crackling of thorns under a pot, of which Solomon speaks." Solomon makes use of the image for purposes of comparison, but Prof. Huxley politely abstains from proceeding further into detail.

The study of Biology which is here advocated is practical study of the actual phenomena presented by plants and animals.

"Nobody will ever know anything about biology, except in a *dilettante* 'paper-philosopher' way, who contents himself with reading books on botany, zoölogy, and the like; and the reason of this is simple and easy to understand. It is that all language is merely symbolical of the things of which it treats; the more complicated the things, the more bare is the symbol, and the more its verbal definition requires to be supplemented by the information derived directly from the handling, and the seeing, and the touching, of the thing symbolized—that is really what is at the bottom of the whole matter. . . . You may read any quantity of books, and you may be almost as ignorant as you were at starting, if you don't have, at the back of your minds, the change for words in definite images which can only be acquired through the operation of your observing faculties on the phenomena of Nature."

The *rationale* of the demand for *practical* teaching in all branches of science—a demand to which it is exceedingly difficult to get those who have the direction of educational institutions in this country to accede—has never been stated with more simple force than in the above extract.

Like all his writings, this last volume by Prof. Huxley presents

him to us in the aspect of a sure-footed resolute guide who, with a firm hand, takes us up an endless variety of the peaks of social and scientific problems, hard to be scaled. He brings his reader skillfully up to the summit, explains the prospect, and carefully deposits him again in his proper place. There are few excursions, where a little exertion is needful, so exhilarating and profitable, so much to be recommended to the traveler among questions of the day, as those which are accessible through the good offices of Prof. Huxley.—*The Academy.*

SPECIMENS OF EDUCATIONAL LITERATURE.

By F. W. CLARKE.

AMERICA is unquestionably preëminent in educational matters. It has more schools and a greater variety of schools than any other country on the face of the earth. Some of these schools are extremely remarkable. You cannot match them elsewhere. They thrive only upon the freest soil, untrammeled by effete conventionalities. Throughout the West and South they spring up abundantly, as if in proportion to the fertility of the land. The New England and Middle States are too much tied down to routine and tradition to produce such rare developments of the intellect. Such schools deserve to be more widely known and more generally appreciated. We propose to help some of them to a broader fame, by printing a few extracts from their circulars and catalogues.

First in order let us take some clippings from a little pamphlet issued by a school in Faribault, Minnesota. This circular is remarkable for its clear expression of views upon a variety of educational topics, and for the suggestions it offers concerning real school discipline. Here are a few of the wise regulations:

"Scholars with any contagious trouble or disease are not allowed in the school till cleaned, or till their disease is beyond danger.

"If a snow-storm is up, the teacher takes the privilege to dismiss the school earlier in the afternoon than it otherwise would have been.

"It is not allowed to scholars to jump on to or hang to teams except on the way to or from school, and then only with the permission of the driver.

"Anything belonging to the school-house or to the scholars, broken, torn, or damaged, must be paid or restored by the scholar or scholars who have done it, as well as by those who were accessory to it.

"Where a punishment is in order it will be applied whether a scholar's parent or any visitors are present or not."

And so on for about twelve pages. The remarkably concise and exact wording of these valuable rules must attract the attention of every teacher. The circular closes with a four-page essay upon "The

Affairs of Education," from which a few slips may be culled. The author holds that it is very unwise to be "lenient, indulgent, unconcerned, or superficial, in school-keeping," and considers it extremely wrong to resort to "a false show of unmasticated, unprepared, unfit, and undigested accumulation of stuff and material, producing neither educational bone, or muscle, or nerve, and crammed in, drummed in, or infused, as with a funnel, in a hurry, or in the worry and flurry of an unquiet, unconcerted school."

Who, understanding this, can doubt it? Or who can doubt that the confidence of the pupils in the teacher "renders them more apt to conceive how much they are bound in gratitude to parents and teacher, and to get aware of the depth of the contrast and abyss of their real course and nature of action and that what it should be, and thus makes them more studious to be grateful and to advance their own interests as scholars?"

The teacher of this school, like most other Germans, believes in systematic thoroughness. "But," says he, "this does not mean that in the system that promotes perception, thorough thinking and reasoning, understanding, memory, self-reliance, deceitless ennobling enlightenment, and well-digesting progress, a scholar gets along slowly over the ground or through the books; on the contrary, while it excludes headway on the skip and jump, as each point is completely learned and mastered, it makes the next depending on this so much easier and more quickly grasped, and in a short time, what puzzles and discourages others, becomes to him the greatest delight; and thus he progresses from point to point, from page to page, from combining to combining the known with the unknown, the former unlocking and explaining the latter, and so he moves faster and faster, leaving the half-tutored, unsteady fustians far back in the distance."

The last citation which I shall make from this document might be construed into a rap at myself:

> "It would be malicious folly without self-respect, to detach parts of this circular from their dependent connection with others that explain their spirit and application, and then to pervert their true construction; hence it is not intended for such persons," etc.

On second thoughts, however, this passage can refer only to those who have criticised the school and made light of its methods. "Let the galled jade wince, our withers are unwrung." We can only express our admiration for such an extraordinary "well of English undefiled," and for the profundity of the ideas contained in it.

Another school of peculiar interest is the Mars Hill Academy, near Florence, Alabama. The "permanent circular" of this institution, now before me, bears date 1872, and contains many points worthy of quotation. The merits of the school are well emphasized by the following paragraph:

"J. M. Cunningham, of Hamburg, Tennessee, boarded *one son and two daughters* at the Institution during the first session. During the second session he boarded *one son and four daughters* there. He seemed to regret his inability to do more for the school, but considered *little Emma, the baby,* rather too small to send to a boarding-school. He thinks, however, that the school is a good one, and deems it the duty of those who are blessed with more children than himself, *to lend a more helping hand. He is a man whose judgement and patronage are both valuable.*"

This remarkably italicized passage shows at once that Mars Hill Academy believes in the coeducation of the sexes. In another portion of the circular, however, we learn that, although the boys and girls are frequently brought into the presence of each other, the strictest care is taken "that all observe a proper distance." Furthermore, every pupil signs an elaborate pledge never to "seek or accept a private or secret conversation or correspondence with any pupil of the opposite sex from my own, and that I will never receive a proposition for such correspondence or conversation, or anything tending thereto, without immediately committing the same to the principal," and so forth, and so forth, and so on. Thus we see that coeducation, at least in this school, can hardly be considered dangerous. The morality of the scholars is also advanced by a Scriptural exercise of an hour in length every morning before breakfast. Here is a part of the result:

" At our last examination we examined the Bible class before the public for *one hour* without one unsatisfactory answer being given, and might have continued the examination with honor to all the members for *four hours.* They could tell with ease the number of *books* in the old Bible; the numer of *books* in the New Testament; the number of *chapters* in each; the number of chapters written by various writers; the name and order of *every book in the entire Bible;* the number of chapters in every book in the entire Bible; the *origin* and *meaning* of the names of the books; the *history of the creation* in detail; the history of the *first family;* the history of the *flood;* the history of Abraham, Isaac, Jacob, the twelve patriarchs, etc.; the history of the Egyptian bondage and deliverance; the number and order of the plagues of Egypt; the history of Sodom and Gomorrah; the beautiful, thrilling, story of the Cross, etc."

But the crowning glory of the school is to be found in the certificate given to every student at the end of his or her course. It is described thus:

"To every pupil, great and small, will be presented a VERY ELEGANT CERTIFICATE, containing a concise statement of the progress of the pupil, with the name, State, county, and post-office, of the same. These certificates are very beautiful; they are beautifully printed in *four colors.* In the centre is a representation of the earth, showing the equator, tropics, and polar circles. Around the horizon of the northern hemisphere is printed in green, 'Blessed are they that do His commandments, that they may have right to the tree of life, and may enter in through the gates into the city.' The southern hemisphere is bounded by—'Fear God, and keep His commandments, for this is the whole

duty of man.' Within this circle is beautifully arranged the following certificate:

"'This is to certify that M——, of —— county, ——, a good, kind, obedient, moral, studious, courteous, worthy, and honorable pupil of Mars Hill Academy, near Florence, Alabama, has attained a high degree of proficiency in ————, and is hereby recommended to the public as eminently worthy the confidence and esteem of every member of any community in which h— lot may e'er be cast, if future life does not corrupt h—.'

"This is surrounded by four hearts, two in red and two in green, and *eight beautiful, appropriate illustrations.* The words *Faith*, *Hope*, *Charity*, and *Heaven*, are printed in green and red within the hearts, in *Greek*, *Latin*, and *English.* Surrounding the heart on the north is the motto, 'Labor conquers all things,' in three languages. The name of the Institution on the south in three languages. In large and beautiful variegated characters the name and location of the Institution appear on the top and bottom of the certificate. All the space not otherwise filled is occupied by most beautiful and appropriate passages of Scripture. The whole is surrounded by a neat border, ends with the benediction of the Principal, and will be presented to each and every pupil, *elegantly framed*, so that it may be worthy of a conspicuous place in the most fashionable parlor. Size of frame, sixteen by eighteen inches."

Who, after reading this, does not long to possess just such a certificate?

All things considered, the most remarkable specimen of educational literature yet issued is the catalogue of Neophogen College, at Gallatin, Tennessee. This catalogue has no rival: it can never be excelled, and probably will never be equaled. It begins with a map of Sumner County, wherein the college is situated. Then come four woodcuts representing "honor-students," young gentlemen, a likeness of the college-president, John M. Walton, LL. D., and then four more effigies of "honor-students," young ladies. These woodcuts are unique. The next feature of interest in this pamphlet is the page devoted to the Faculty. Here the predominating name is Walton; it occurs no less than five times, although apparently but three individual Waltons are indicated. There are also a number of blanks indicating vacant professorships, not waiting, of course, for endowments, but for men of sufficient ability to fill them. Among these blanks we find the title of "Professor and Master, School of Phrenology, Physiognomy, and Hygiene." What a pity that so important a chair should be empty! But we find some compensation for this misfortune when we see near the bottom of the list the name of an estimable lady inserted as "Mistress of Cuisine and Hygiene."

After a long (and to the general reader uninteresting) list of students, with their marks for "application," "punctuality," and "deportment" appended, we come to a few pages of text. Here we learn much of the character and position of Neophogen. We are informed, for example, that it is a "National University," being "centrally located between the North and the South, the East and

President of Neophogen College.—(*From the Catalogue.*)

the West." Besides, "it is within a few hours' ride of Epperson, Red, Castalian, or Tyree Springs. Any kind of mineral water can be had at the College, if desired."

But piecemeal quoting is useless; we need a longer sample of this descriptive part of the catalogue. Let us take a page at once, with all its headings:

"The Two Cumberlands,

with banks and crests adorned by the noblest monarchs of the forest, and embracing the lovely valley between, make the land of the poet's dream and the home of the artist's heart.

"Health and Wealth

are here combined with 3,500 citizens, who cannot be surpassed for intelligence and refinement.

"No Parallel

can be found (estimating the population) to the ten first-class turnpikes leading into this little city of enterprise. These fine roads are valuable auxiliaries to

HONOR-STUDENTS OF NEOPHOGEN COLLEGE.—(*From the Catalogue.*)

the school, for they can be made to contribute to the health and pleasure of both the students and the faculty.

"THE SCENERY

is most beautiful and romantic. In a single glance, from a central point, the eye surveys an ellipse, the circumference of which is 150 miles; and 'outstretching in loveliness'—the lawn, the woodland, the meadow, the town spread out beneath, the gushing rills, the flowing rivers, the farm-houses scattered here and there, the rugged cliffs—all make up a landscape which is at once picturesque and sublime. The future home of Neophogen was not selected without canvassing the advantages and inducements offered at all the most noted points in our country.

"THE COMMUNITY.

We claim for the citizens of Gallatin and vicinity that true virtue and magnanimity found alone in the most refined society.

"Here, identity is lost in public spirit. Here, a studious observance of the rights of others is ever manifested. Here, the principles fostered by those noble old pioneers are infused into the minds of their successors.

"Here are the descendants of those worthy spirits—the Winchesters, Trousdales, Jacksons, Peytons, Wynnes, Halls, Guilds, Turners, Barrys, Heads, Blackmores, Lauderdales, Bledsoes, Babers, Allens, Bennets, Blounts, Elliotts, Odoms, Dismukes, Blythes, Millers, Donelsons, Williamses, Boyerses, Bates, Montgomerys, Smiths, Duffys, Boddies, Glovers, Alexanders, Waltons, Kirkpatricks, Deshas, Blues, Winstons, Tomkinses, Houses, Hallums, Rascoes, Bakers, Greens, Stuarts, Wilsons, Wallaces, Moores, Joyners, Buggs, Franklins, Cantrells, Looneys, Hassells, Harrises, Malones, Pattersons, Parkers, Kings, Johnsons, Shutes, Guthries, Cottons, Branhams, Douglases, Bells, Tyrees, Martins, McCoins, Harts, Cages, with many other names worthy of emulation, and the half is not told.

"While we studiously ignore the idea of aristocracy and nobility, our minds are pleasantly associated with dignity and purity."

All this information is evidently just what a careful parent would require. The healthiness of a college town, and the character of its people, must be important to every father having a child to educate. As for the qualifications of the professors, the following passage is sufficiently suggestive:

"What is the duty of many, is generally neglected by all. Here is *continued* and *special* stimulus to president and professors; here are no easy and assured positions, with fixed and positive salaries, but they depend upon the patronage, prosperity, and reputation of the institution. That this should be so, is too obvious for comment. A very little knowledge of human nature is necessary to see why. To each teacher it is plain, the greater the labor, the greater the reward."

This passage is also instructive: "Learned men who have failed in business are tendered every inducement to take a life-home here. We intend to take the most active measures, and use every exertion, to raise a large life-fund for the relief of unfortunate literary men. Let them have homes, and the society of congenial spirits."

After the "curriculum," in which many studies are laid down with numerous text-books for each, comes a list of optional studies, with the extra prices affixed. Here we find "music on harp" quoted at $30, and "comparative philology" at $7.50. Italian, French, Spanish, and German, are ten dollars each; so that comparative philology may be regarded as given at a wholesale price. Languages are so much cheaper in a bunch than they are singly.

But the degrees given at Neophogen afford one of the most interesting items concerning the college. They are eighteen or twenty in number, and among them some are of considerable novelty. For example:

"A. M. will be given to any male, and M. A. to any female, who, after having received A. B., shall also graduate in penmanship and book-keeping, phonography and mnemotechny, comparative philology, and Anglo-Saxon, and in French, or German, or Spanish; and to a B. S., completing these same (preceding) additional or extra studies, the degree of M. S. (Master or Mistress of Science).

"M. E. L. (Master or Mistress of English Language), to any student graduating in the schools of humanities, and of history and moral science; and in common-school written arithmetic, elementary algebra, geometry, and the trigonometries and mensuration; in political economy and metaphysics; in penmanship and book-keeping, phonography and mnemonics, comparative philology and Anglo-Saxon.

"B. A. LL. (Bachelor (or Maid) of Ancient Languages).

"B. M. LL. (Bachelor (or Maid) of Modern Languages).

"B. M. (Bachelor (or Maid) of Music), to any graduate in music.

"B. M. and D., in Music and Drawing.

"B. M. and D. and P., in Music and Drawing, and Painting.

"B. F. A. (Bachelor (or Maid) of Fine Arts), to graduate in the three preceding, and also in wax-work."

But mere quotations cannot do full justice to this extraordinary catalogue. I will, therefore, give only a very few more, quite hurriedly, and leave the reader to seek for fuller details in the original document. Under the head of "specialties" a variety of studies are given, English, elocution, oratory, and typography, being made especially prominent. As for etiquette, this passage will speak for itself:

"It is not a matter of choice, but compulsion. The course of training in etiquette is, in great part, original. It has been said that manners make the man; if not true, they at least cannot be neglected. Here it is the theory with continued practice. We think we have the politest students in America. The salutation, the bow, the courtesy, the word, the tone, the look, the inflection—vocal and physical; the attitude, the hand, the feet, the spine, and the eye, are all observed and studied, and the students daily exercised in them."

Another passage of striking merit runs as follows:

"What has brought discredit upon diplomas of this age? What so greatly reduced the respectability of the word graduate in this age of nostrums and charlatanry? *Answer.* Silly parents, and incompetent and unscrupulous teachers.

"Parents that are content to purchase the labeled casket without the jewels; parents that are in many cases deceived themselves, and in other cases willing to deceive. Some reason thus: 'I have children, my children must be graduates, it is respectable.' Crœsus speaks, or intimates unmistakably, and it is done. There must be radical reform here. Common, old-fashioned honesty demands it. It must not be. The vital interests of our country cry aloud against it.

"We must steer aloof from making these pinchbeck and galvanized scholars. This will be very pleasant to the eyes of all honest, earnest, and competent teachers. We are all presidents and professors these days; but we have an uncontrollable fancy for those noble old words, 'teacher' and 'school.'"

The social importance of coeducation is shown thus:

"The young ladies and gentlemen are permitted, we may say required, to have interviews in the drawing-rooms twice in each month. The refining, elevating, and stimulating effects of these evening associations, regulated by system and class rotation, must be seen to be appreciated."

The moment we consider that the young ladies wear "green-calico dresses and white aprons" for a school-uniform, we cannot doubt the impressiveness of these interviews. Further on we find that prizes are given at Neophogen for "neatness," "grace," "true modesty," and "etiquette;" and the names of the "fortunate winners" are appended. The catalogue closes with two pages of "opinions of the press." A single specimen will do to illustrate these:

"The teachers of Neophogen College have the highest national reputation, both as teachers and authors. It is the cheapest college of the kind in the world, and is the best one for the males and females of the North and the South. It is located in a beautiful section of the State, which was selected with great care."—*Republican Banner* (*Nashville, Tenn.*)

These extracts sufficiently indicate the remarkable character of Neophogen. Who, after reading them, can longer doubt that the South is in earnest in this great matter of education? Let the boastful educators of New England bow their heads, and humbly confess that they can never hope to parallel such schools as the Mars Hill Academy and Neophogen College!

THE PSYCHO-PHYSIOLOGICAL SCIENCES.

By JOSEPH RODES BUCHANAN, M. D.

THERE has ever been, and probably for another century there will continue to be, an "irrepressible conflict" between those whose conceptions of Nature are limited by sensation—who recognize no existence but matter and motion, who trace all that exists to material causes alone—and a very different class of thinkers, who trace

causation beyond matter, who discover causes that are not material (called spiritual), who believe that the Great First Cause (the Unknowable of materialists) is an infinite spiritual power or basis of all things, and who recognize in man also a spiritual power of which they are conscious, widely different from matter, partaking of the nature of the Divine, and, being a very positive entity—the greatest of all realities to us—destined, in accordance with the doctrine of the persistence of force, to a duration analogous to that of matter.

To the materialist, who finds in matter "the promise and potency" of all things, there is no higher object of reverence and love than the examples of men and women within his reach; there is no future life to compensate for the wrongs and sufferings of this, the triumph of fraud, or the unmerited agonies of disease and poverty; there is no apparent controlling purpose of benevolence or justice in the universe, but only a chance medley of strife, in which strong-handed selfishness is best rewarded, and when "man dies as the dog dies" the account is closed, and the self-imposed martyrdom of the loving hero appears a final loss and folly.

To the spiritualist, the universe has a deeper meaning, a nobler destiny. The wisdom of the Infinite, which is unutterably beyond his reach, is a consoling reality, and the little play upon this theatre, the life-struggle of threescore and ten years, is but the beginning, the gestation and birth of a career corresponding to our noblest aspirations and our faith in the Divine benevolence.

Man has such immeasurable powers of adaptation that a strong moral nature may exist under the gloomiest views of materialism (which naturally tend to the pessimism of Schopenhauer and Hartmann), and sustain itself by its constitutional energy and buoyancy; but there are millions to whom materialism teaches the daily lesson that to "put money in thy purse" is the chief aim of life, and to riot in sensual pleasure on ill-gotten gain, until the candle burns out, is the best wisdom.

The glow of hope, the removal of anxiety, the exaltation of happiness, the enlargement of sympathy and love, which thousands have experienced when they have passed from the dark nescience of materialism to the brilliant certainties of spiritualism, and learned the grandeur of human destiny—whether the change has been effected by emotional eloquence and historical argument in the bosom of the Church, or by scientific investigation and experimental inquiry in pneumatology, or by that direct perception of spiritual existence now enjoyed by a few (and destined to be enjoyed by all when the human race shall have attained maturity of development)—should satisfy any impartial thinker that the diffusion of spiritual knowledge is as noble and practical a form of philanthropy as a good man can labor for.

But, in laboring for these ennobling truths, he encounters a strong resistance in the animal nature of man, in the selfish and depressing

character of our daily toils, and in the too great concentration of attention upon physical sciences, to the *exclusion* of those in which a psychic element is found. The study of physical science alone is no better preparation for psychic studies, which employ different faculties, than the study of the counting-house ledger or the supervision of a pork-house would be for the service of Parnassus.

A recent publication from Dr. Carpenter, embodying two lectures on psychic subjects (mesmerism, spiritualism, etc.), presents, in the most offensively exaggerated form, the pragmatic pretension of certain *physical* scientists to take charge of *psychic* investigations with an air of more than papal infallibility, and an emphatic notice to all the rest of mankind, not only that they are incapable of such investigations, but that their opinions, their testimony, and even their oaths are not entitled to claim a feather's weight before the self-created tribunal of which Dr. Carpenter is the authoritative mouth-piece.

The magniloquent insolence of such a proclamation would be amusing enough, even if Dr. Carpenter were, as he fancies himself, an expert of great skill; but when he is dealing with a subject of which he knows far less than thousands of the most enlightened people, far less than many men of science who are his peers in intelligence and his superiors in candor and in philosophic habits of thought, his insolent assumptions of superiority and denial of their claims to veracity and intelligence, whenever in conflict with his own theories, are all that his most unfriendly opponent could desire in order to demonstrate his utter unfitness for the task which he has assumed.

Passing by his ludicrous claims to a boundless superiority over contemporary scientists who do not follow his lead, we may ask whether he has any claims whatever to be recognized as an expert, whose opinions on these subjects have any especial value. Eminence as a physiologist does not imply eminence or capacity as a psychologist. It is true, physiology and psychology are coterminous sciences; but until recently their cultivators have kept as wide apart as the antipodes. Psychology has been prosecuted as if man never had a body (and ultra-psychologists do not admit that there is a human body or any other material existence whatever), while physiology has been cultivated in the same ultra spirit of nescience, as if man had no soul. So thoroughly does a feeble or a narrow mind, in fixing its attention on one object, lose sight of everything else. Dr. Carpenter himself has expressly excluded the soul from the pale of science, which is the next thing to excluding it from cognition, and one of the most recent voluminous and learned American works on physiology excludes it entirely, and substitutes the physical action of the brain, as follows: "The brain is not, strictly speaking, the organ of the mind, for this statement would imply that the mind exists as a force, independently of the brain; but the mind is produced by the brain-substance" (Flint's "Physiology of Man," Nervous System, p. 327).

Thus physiologists generally regard mind as purely phenomenal—as something holding the same relation to the brain as music to the violin, when the violin plays itself. If the relations of the brain to paralysis or to digestion are under consideration, such physiologists may be recognized as experts; but when its relations to a soul of which they know nothing are under consideration, we may very properly say to them, "*Ne sutor ultra crepidam.*"

Of course, materialists cannot deny that mental *phenomena* exist, but to them they are simply the phenomena of matter. Dr. Carpenter may even admit the existence of a soul beyond the pale of science—a quiddity as distinct from the real soul as Spencer's "Unknowable" is from any conception of a God. Practically speaking, Dr. Carpenter is entirely in harmony with other materialists.

Men of scientific culture, who have spent a considerable portion of their lives in practical investigation and familiarity with the facts of mesmerism, spiritualism, and other psycho-physiological sciences, are experts in the highest sense of that term, and can but smile at the insolence of those who, never having made a successful experiment on those joint operations of the soul and body which constitute mesmeric, spiritual, and other sciences, nevertheless claim, as Dr. Carpenter does, to be recognized as *the oracle* in matters of which his ignorance is both pitiable and ludicrous, having never, by his own confession, witnessed any of the innumerable facts demonstrating an extra-material agency, which, during the whole of the present century, have been accumulated and diffused in all civilized countries, and among their foremost thinkers. His position is precisely that of the principal Professor of Philosophy at Padua, who refused to look through Galileo's telescope, and continued to teach the old theories. Nay, far worse: he not only refuses to see what is open to all men, but, as Horkey wrote against Galileo, while refusing all fair investigation, and thus furnished an example to "point a moral" for posterity—an example of the power of "dominant ideas" in a bigot—Dr. Carpenter repeats the same performance amid the higher enlightenment of the present age, with a perversity and hostility of purpose which were never surpassed by the blind votaries of Aristotle. And as Horkey detected the trick in Galileo's telescope which made stars by reflected light, Dr. Carpenter too detects fallacies in the experiments of Prof. Crookes, whose temperate and candid reply places him in even a worse position than that of Martin Horkey. (See *Nineteenth Century* for July.)

In a question of the existence of certain facts, the honest witness who, without prepossession, investigates and follows up the facts wherever they are visible, is competent to instruct us; but he who carefully avoids coming into close contact with the facts, and, while maintaining his mind in undisturbed ignorance, feasts upon second-hand gossip and stale calumnies, which he retails with delight, is hardly entitled even to a nod of recognition among honest inquirers.

When Home was in England, and gentlemen of unimpeachable veracity and superior intelligence saw him lifted from the floor by an entirely invisible power, why would not Dr. Carpenter witness such an occurrence? When Slade was in England, of whom gentlemen of intelligence say that when a pencil was placed between two clean slates fastened together, which were left in full view of spectators in broad daylight lying on the table, messages were written on the inside of the slates, of a highly intelligent and appropriate character, why did Dr. Carpenter, if he possessed the sentiments of honor and love of truth which mankind generally recognize as commendable, refuse to make the simple and brief investigation which would have determined in an hour whether his theories and his stale calumnies had any foundation or not?

The truth is, Dr. Carpenter and men of his character care mainly for their own personal infallibility: they seek only the vindication of their own theories, *per fas et nefas*, and do not approach an experimental test unless they are permitted to interfere and dictate some method of conducting experiments to hinder or delay their progress. But when a simple experiment is proposed which cannot be intermeddled with, and which is completely and forever decisive, such as the levitation of a table or a man to the ceiling, no one being in contact with the lifted object, or the production of writing upon the interior of two clean slates which the inquirer brings himself, firmly secured together, the pretentious dogmatist is very careful to keep out of reach, no matter how he may be importuned or challenged. He generally fortifies himself with a few contemptuous phrases and a determination to see nothing of the marvelous.

The public that employs and patronizes men of science has a right to expect from them fidelity to truth and vigilance in seeking it—not cunning in evading or skill in calumniating true discoveries, followed by contemptuous neglect when their claims have been demonstrated. Such is the course pursued by some toward all discoveries in which psychic powers are involved. There is a fossilized materialism in many minds, which has become a matter of blind feeling, utterly irrespective of facts or science, against which it is vain either to reason or to offer facts. In the last resort the skeptic declares, "I wouldn't believe it if I saw it myself."

Of this vicious state of feeling, producing an incapacity to reason correctly on certain subjects, we need no better example than Dr. Carpenter himself, as exhibited in this *brochure* of one hundred and fifty-eight pages, the substance of which may be condensed into four propositions:

1. History exhibits a great deal of folly, superstition, and ignorance, and a great many preposterous narratives of witchcraft and silly miracles, attested by many witnesses: *therefore*, in the present enlightened age, human testimony is of no value when it affirms any-

thing out of the usual course of Nature (as observed by Dr. Carpenter), and the scientific testimony of Profs. Crookes and Wallace (reënforced by that of eminent men and women in Great Britain, France, Germany, Spain, Italy, and the United States, whose numbers and moral and intellectual capacity would outweigh any Royal Society or French Institute), is of no more value than the most fanciful mediæval legends of Catholic saints, which science does not condescend to notice.

2. Some individuals can be brought by a proper operator into a waking mesmeric condition of passive credulity and obedience to the voice: *therefore* we should believe *everybody* liable to this condition, and believe nothing that anybody tells us which is different from the usual course of Nature, *as Dr. Carpenter understands it.*

3. The usual course of Nature under our own observation—we beg pardon, *Dr. Carpenter's* observation—*is all of which Nature is capable*, and no new laws or agencies which Dr. Carpenter does not know are to be expected or developed by investigation. Whoever asserts that any such laws or agencies exist, is to be regarded as a liar or a victim of hallucination; and, in fact, the chief phenomena of mesmerism and spiritualism have been discovered to be cheats.

4. Mesmer advanced certain preposterous and unscientific pretensions; certain mesmeric operators have made failures; and Dr. Carpenter affirms that he has several times failed to discover any clairvoyance in celebrated clairvoyants, and has detected some pretenders to clairvoyance as impostors: therefore, mesmerism is a delusion.

It is difficult to treat such a mass of absurdity and misstatement with the gravity and courtesy appropriate to scientific discussion. When a dogmatic adult insists on proving to us that the earth is entirely flat, he takes rank, as a first-class bore, with Dr. Carpenter; and the only method of disposing effectively of such nuisances is that adopted by Mr. Alfred R. Wallace—a heavy wager to be settled by actual measurement of a portion of the earth's surface. If Dr. Carpenter had courage enough to endure the wager-test, he too might receive his *quietus* from Mr. Wallace. But there is no hope of that; the large reward offered in England, to any one who will produce certain spiritual phenomena by physical means, will never be called for.

The first proposition may pass for what it is worth. If there are any who agree with Dr. Carpenter in his assumption that the superstitious tales of an ignorant age are as worthy of credence as the elaborate investigations of the most distinguished scientists—men whose testimony would be decisive in any court of justice where life was at stake—it is not worth while to reason with *them*. The assumption of Dr. Carpenter is slanderous against his distinguished scientific opponents; but its extreme silliness renders it entirely harmless to any but himself. The same argument would destroy the credibility of medical, surgical, and physiological works of to-day, because

the medical records of former times contain much that is absurd and incredible.

The second proposition is but little better than the first. There is an unfortunate development of brain which makes or marks the constitutional and *incurable* bigot, to whom bigotry is philosophy. The Italian philosophers who denounced Galileo, and the French physicians who laughed at Harvey, were as unsuspicious of their own mental defects as Dr. Carpenter. Could anything but the blinding impulse of bigotry induce a man of great intelligence, age, and experience, to confound possibility with certainty in this ridiculous manner — to affirm that because certain individuals can be mesmerized in the American manner, wide awake, but passive creatures of the operator's voice, therefore we should consider *all men* liable to this condition, and treat all testimony that contravenes our *opinions* of the course of Nature as the testimony of helpless mesmeric subjects? By an exact parity of reasoning we may say certain individuals in every community have committed, or might commit, murder: therefore, whenever we find any one dead, and do not know how he died, we may assume that the men or women who were in his vicinity murdered him.

But suppose Dr. Carpenter should witness a case of levitation, and have the honesty to report what he saw, shall we then hold him to be either a mesmerized dupe or a confederate knave—which would he prefer to be called? Dr. Carpenter *may be* sincere, but he speaks quite reverentially of the Scriptures, although by his own declarations he must regard their miracles as shams which had never been exposed by a learned expert; and their spiritual phenomena, so analogous to those of the present day, as base impostures.

The third proposition, considered as a work of art, is an ingenious compound of evil, on which his satanic majesty might smile in grim approbation. Dr. Carpenter's language is as follows: "My contention is, that where apparent departures from them [the laws of Nature] take place through human instrumentality, we are justified in assuming in the first instance either *fraudulent* deception, or unintentional *self*-deception, or both combined—until the absence of either shall have been proved by every conceivable test that the sagacity of skeptical experts can devise."

As for himself, he affirms that he has "no other theory to support than that of the well-ascertained laws of Nature;" and further, that "it is quite legitimate for the inquirer to enter upon this study with that 'prepossession' in favor of the ascertained and universally-admitted laws of Nature which believers in spiritualism make it a reproach against men of science that they entertain."

If this be a true and honest statement of the case, there is no case in court for discussion: Dr. Carpenter is a philosopher, and the spiritualists are hopeless fools. By what muddled process of thought he could bring himself to make such a statement, we need not inquire.

There is not a scientific spiritualist who would not repudiate the statement as calumnious. If the laws of Nature can be violated, there is no absurdity or chimera which is not admissible; but, instead of believing this possible, spiritualists are the foremost of all men in insisting on the universal inviolability of all the laws of Nature, extending their infrangible power not only over all physical phenomena, but throughout the equally extensive psychic realm (in spite of all metaphysical speculations to the contrary)—an extension which Dr. Carpenter has not affirmed himself.

Dr. Carpenter *presumes* that liberal thinkers must be at war with the laws of Nature, because *he thinks* those laws incompatible with the new phenomena. The obfuscation of his mind is the same which has characterized narrow-minded bigots in all ages. The narrow-minded man cannot conceive two widely-different truths at once, and perceive their harmonies: he adopts one with zeal, and rejects the other firmly, because he thinks them incompatible. Narrow-minded men are of course bitter partisans, and the great majority of mankind from defective brains and irrational education see only one aspect of truth, and reject all others.

Dr. Carpenter sees no truth in mesmerism, and Baron Dupotet sees no reliable truth in medicine; Hahnemann rejected the entire accumulations of allopathy, and the old school indignantly rejected Hahnemann's discoveries as nonentities. A doctor who administers three-grain pills will not tolerate homœopathic pellets; and he who has discovered that infinitesimals will cure is often equally intolerant of the three-grain pills: and so they call each other quacks and impostors, in the same spirit in which Dr. Carpenter assails those who see more of the truth than himself, and are equally interested in psychic and physical facts. How long shall it be before the "survival of the fittest," or the improvement of education, shall give us a generation with brains enough to entertain two ideas at once?

The difficulty of Dr. Carpenter and all other narrow-minded people lies in the poverty of their conceptions. They have no idea that it is possible for Nature to show her powers in any new way to which they are unaccustomed. Hence, the ascent of a balloon seemed miraculous to the ignorant peasants, who took it for the work of the devil; and the formation of a solid block of ice from water was a similar violation of Nature's laws to the Asiatic despot, who felt justified in treating the traveler as a liar who told him of it. Had Dr. Carpenter been his prime-minister, the traveler might have fared worse.

There is no better evidence of philosophic imbecility than a sentiment of the all-sufficiency of our present meagre knowledge of Nature. The proposition of Dr. Carpenter that all new, marvelous facts shall be treated as impossibilities, and the witnesses who, without any other motive than the love of truth, attest them at the expense of their own popularity, shall be treated as impostors (which means, made personally

infamous and consigned to the mercies of antiquated laws), embodies all the impulses of stolid ignorance and malignity which have in past ages warred against science and innovation by prisons and by death-penalties.

Every great discoverer introduces something to human knowledge different from the usual understanding of Nature, and is, therefore, by the Carpenterian rule, a fit subject for persecution. The rigorous application of this principle would check progress by a war upon the greatest benefactors of mankind—those who lead them into essentially new ideas of Nature. The rule is therefore *thoroughly satanic* in its moral aspect, while in its intellectual character it is *thoroughly stolid*, being a declaration of war against the increase of knowledge in certain directions forbidden by the bull of the materialistic pope.

Considered as an appeal to that great tribunal, the public, this little volume is an extraordinary piece of insolence—what would be called at any judicial tribunal a flagrant contempt of court, entitling the applicant to summary dismissal and punishment. Dr. Carpenter not only pronounces the public, to whom his book is an appeal, incompetent to decide, virtually telling every reader that he has no right to an opinion on what he has seen until Dr. Carpenter (or some one whom he recognizes as a colleague) has told him what to think; but he assumes, like a "border-ruffian," to expel every witness from court who testifies differently from himself. No matter how pure the character, or how lofty the intelligence, if they disagree with him they are falsifiers; but, as to all who agree, their testimony is valuable, no matter how contemptible its source.

It is pitiable to see a gentleman of Dr. Carpenter's standing reproducing the obsolete trash which public intelligence had buried in oblivion. The toe-joint and knee-joint theory of rappings was speedily exploded in America, and has scarcely been heard of for twenty years. Rappings have occurred in thousands of families, in spite of their incredulity, and compelled them to recognize an invisible power which acts sometimes with force sufficient to break furniture, and to be heard at considerable distances. As Dr. Carpenter manifests a remarkable ignorance of the progress and present status of spiritualism, it is probable he does not know that the joint-rapping certificate to which Mrs. Culver's name was attached was refuted immediately after its publication. The *séances* she describes never occurred at all, Catharine Fox being at that time seventy miles distant at Auburn. How unmanly, how much like a malignant village gossip, in Dr. Carpenter to dig up decomposed slanders, when the lady concerned, now Mrs. Jencken, was in London, and he might at any time have satisfied himself in an hour of the reality of true spirit-sounds and other phenomena!

Throughout his long career, Dr. Carpenter has kept himself willfully ignorant of mesmeric and spiritual facts, which are easier of access

than almost any other scientific phenomena. He has reproduced the career of Horkey with remarkable fidelity. No sincere inquirer has ever failed, if he made proper efforts, to obtain evidence of an active intelligence which is not material. In my first interview with a medium, over twenty-five years ago, loud sounds—not raps, but sounds like the creaking of a wooden mill—were freely produced at request in a small uncovered table in our parlor, when no person was in contact with it or within three feet of it. On making careful examinations, the sounds appeared to be developed in the loose marble slab which constituted its top, and, by feeling the slab on both sides, I could locate the sound and vibration with great accuracy in its centre. When no one was touching the table, it was held down by the spirit-power, when requested, with a force which I estimated at twenty pounds in lifting it.

But it is entirely useless to mention any such facts to bigots of the Carpenter class, or to sustain them by any amount of testimony; for to them all testimony is worthless concerning anything outside of the limit which Dr. Carpenter has marked off with a grand Cardinal Richelieu flourish, as the impassable limit where inquiry must halt and vituperation begin.

Great is the power of the speculative scientific dogmatism which enabled Dr. Carpenter to show in his "Physiology" that one hundred pounds of starch would support the life of a savage as long as four hundred pounds of venison or other game (Chapter VII. Of Food and the Digestive Process), although it would be as difficult to convince the unscientific savage that such an opinion is preferable to experience as to convince Crookes, Wallace, Flammarion, Hare, or even Victor Hugo, that Dr. Carpenter's *opinions* are preferable to their own careful observations.

Worthless as this book seems as an argument, and amusing as it is to those at whom it is aimed, it has some power for mischief—the power of a demoralizing *example*—the power of position and reputation in giving a quasi-respectability to that which is philosophically silly and ethically corrupt. The most demoralizing influence which proceeds from a thoroughly depraved society is the doctrine that all men are knaves or fools, to which Dr. Carpenter has given his active cooperation—saving only a few self-styled "experts" from this satanic maxim. His unfair example is corrupting to scientific literature. The vast amount of mesmeric facts, which could scarcely be summarized and classified in the limits of his book, has been carefully ignored, and his readers would not suspect their existence, if dependent on him for information. Yet, as he is such a stickler for the scientific qualifications of witnesses, why could he not even *allude* to the testimony of Prof. Agassiz, who ranks before the world *at least* as high as himself? Prof. Agassiz was thoroughly mesmerized by the Rev. C. H. Townshend, and his letter describing his sensations and condition during the

process (February 22, 1839) is published in Townshend's "Facts in Mesmerism."

As the limits assigned this essay do not admit a complete review of this little book, it may now be dismissed, but not to oblivion, for it is destined to survive all other writings of Dr. Carpenter, and to be remembered as long as Horkey's letter against Galileo. Posterity will be amused to think that Whately's "Historic Doubts" concerning the existence of Napoleon Bonaparte, written for amusement, were more than matched by Carpenter's doubts of the existence of any mesmeric or spiritual facts, written in all the earnestness of a dogmatic and infallible philosophizer. In the struggle between stubborn vituperative materialism and comprehensive science, the battle-ground is at the psycho-physiological junction of the two worlds. Man, belonging to both the spiritual and the material world, cannot be properly studied except as a psycho-physiological being, and those who refuse to do this simply ignore anthropology. The effort of ultra-bigoted materialists is to exclude all agencies not thoroughly material—all that is intermediate between the psychic and the physiological—to crush its students and teachers by personal or professional ostracism and accusations of lying knavery and hallucination. The *malignity* of the attacks is sufficient proof that they do not originate in the love of science or of truth, even if they were not often distinguished by mendacity, the mildest example of which is the late assertion of Dr. Forbes Winslow, of London, that "this form of delusion" (spiritualism) "is very prevalent in America, and the asylums contain many of its victims; nearly 10,000 persons having gone insane on the subject are confined in the public asylums of the United States." This is quite *a fair example of the truthfulness* of the majority of the statements on that side of the question. The fact is, however, that the published reports of our fifty-eight insane asylums show but 412 from religious excitement, which is less than two per cent. of the whole number, and but 59 from spiritualism, which is twenty-six hundredths of one per cent. of the whole number in these asylums (23,328).

Dr. Carpenter and the majority of physiologists prefer to cultivate physiology as a purely material science, and reduce man as nearly as possible to a chemical and dynamic apparatus. I have preferred to cultivate physiology in a more philosophic way, recognizing the eternal man who inhabits the body, as well as the transient physical form, and discovering a new class of facts which render our chemical and anatomical physiology far more philosophic and intelligible. What a blind groping in the dark rigidly materialistic physiology appears to one who has gained that full knowledge of our complex constitution which constitutes our *anthropology!* I do not mean by this that mesmerism and spiritualism combined with mechanical physiology constitute anthropology: far from it. Both mesmerism and spir-

itualism are rich but empirical collections of facts, in which there is a large amount of material, but very little that can be called philosophy or satisfactory science.

Anthropology is established by investigating the centre of man's existence—the seat of his conscious life—the brain, in which the spiritual comes into contact with the physical, and is subject to analogous laws. In this theatre of their joint action both may be studied, and we may find that philosophy for which the world has so long been looking in vain, which shall comprehend the entire scope of human existence.

As one of these numerous psycho-physiological discoveries which are receiving daily confirmation from pathology, from autopsies, and from Dr. Ferrier's interesting experiments, I would very briefly allude to *psychometry*, a few experiments in which, if rightly conducted, would dissipate the entire fabric of physiological materialism. The discovery of psychometry and the introduction of the word by myself, thirty-four years ago, have made it quite familiar to liberal minds throughout the United States, and to some extent abroad.

The initial facts which I discovered in 1841, that all who have a high development of sensibility are capable of feeling the influence of any substance held in the hands, even to the extent of perceiving its taste as well as its medicinal effects, led to far more marvelous developments. The supposition of materialism has always been, that when medicines affect the body from contact with the exterior, an appreciable quantity of the substance must have been absorbed into the circulation. Against this theory I guarded by placing the medicines in an envelope of paper, which prevented contact with the cuticle, and concealed the nature of the substance from the knowledge of the subject of the experiment. In making such experiments I found that from twenty-five to thirty per cent. of the persons tried could realize distinct medicinal effects, corresponding to the nature of the medicine. In one of my collegiate classes of medical students (in 1849, some of whom have since occupied honorable public positions), the effects were distinctly recognized by forty-three, whose statement was published at the time. These effects would begin in the hand, ascend the arm to the head, and rapidly diffuse over the whole body.

If the materialist supposes that the substance passed through the dry paper to the dry hand, through its unbroken cuticle and up the arm, I would ask, How long would it take for twenty grains of tartar-emetic or of quinine to be exhaled through the paper? I am not aware that such substances when dry are ever materially diminished in weight by being kept in dry paper.

Omitting other associated facts and philosophy for want of space, I pass on to the consummation, that persons who realize *with facility* these medical impressions can also realize *psychic* impressions of the most subtle character, in such a manner as to dissipate all doubt of the reality of this wonderful power. A manuscript from any source

retains in itself a subtle psycho-physiological emanation characteristic of its writer; and an impressible person with a fair endowment of the psychometric faculty, to such an extent as we would find in perhaps one person in twenty, or, in some southern communities, one person in five, is capable of feeling the entire mental and physical influence of that person as perfectly as if in contact with himself, and describing the individual as he was at the time of writing—his entire mental and physical condition. When there is a high endowment of the psychometric faculty, the descriptions of characters made in this way are more subtly accurate than those from any other source, and the sympathetic impression of the physical condition is so vivid as to develop in the psychometer the pains and morbid conditions of the writer.

In the proper performance of the experiment, the psychometer is not allowed even to see the manuscript, which is used by placing it on the centre of his forehead; nor is he assisted by leading questions. It sometimes happens that, if the character described be one with which the psychometer is familiar, he will finally be able to recognize it, and tell the name of the writer by the identity of the character. For example, while writing this article yesterday, a lady, of considerable intellectual reputation and elevation of character, came in, whom I knew to possess fine psychometric powers. Thinking that I might make a suitable experiment upon her for the illustration of my subject, I selected one of my autographs, and requested her to give me an example of her powers. She knew not what autographs were in my possession, and was not allowed a view of the manuscript, which was placed on her forehead without being seen, and without the slightest hint or suspicion of its nature. In a few moments (holding it to her forehead by her finger) she manifested great mental excitement, and described a character of unusual grandeur and moral elevation. She felt like a great leader to whom multitudes were looking up—a man of commanding stature, of immovable firmness and strength of character, and the loftiest philanthropy. She could hardly refrain from rising up and striding over the floor, from intense excitement. After giving a forcible description of the character, she said she was sure it must be General Washington, as it corresponded to her knowledge of his character, with which she was quite familiar. I then took the paper from her forehead, to let her see this autograph, on which she had been pronouncing:

"*To all to whom this writing shall come.*

"I certifye, that William Morgan Esquire, commands a company of voluntoors in the service of the United States of America.

"Givon at Head Qrs. at Morristown this 25th day of Febry 1777.

"G. Washington."

Ever since my announcement of this discovery, in 1843, I have found it the most perfect agency ever devised for the investigation

of character, and it has become well known throughout the United States. There are as many as a score of practitioners of psychometry who will send a written description of the character connected with any manuscripts sent them, and a number of physicians who, with great success, use their psychometric power for the diagnosis of the condition of patients at a distance.

But experiments and investigations would be entirely useless if Dr. Carpenter could succeed in his aim to build an impassable wall for the exclusion of all *essentially novel* truths, by denying the competency of scientific testimony to introduce new facts foreign to his own cramped conceptions of Nature.

To exclude the multitudinous facts of mesmerism, including the vast number of surgical operations and marvelous cures in which it has been employed by Dr. Esdaile, Dr. Elliotson, and hundreds of others of unquestionable character—to exclude the facts of spiritualism witnessed by millions, and to combine all the incompatible powers of medical and clerical bigotry now, as the Aristotelians and Romish priests combined against Galileo—is a task in which his success will hardly equal that of Lactantius in denouncing the wicked innovations which asserted the existence of the antipodes.

THE DECLINE OF PARTY GOVERNMENT.

By Professor GOLDWIN SMITH.

THE late presidential election appears likely, in its results, to mark an epoch not only in the political history of the United States, but in that of all constitutional countries. In the person of the new President the American Government has come out of party and is trying to be the government of the whole nation. Sir Robert Peel tried the same thing in England, though in his case the "splendid perfidy" to party was less marked than in the case of Governor Hayes, because the repeal of the corn laws was not more essential to the interest of the country, which it rescued from death, than it was to that of the Conservative party, which it rescued from hopeless opposition to the nation and from utter political ruin. Party found a dagger with which to stab Sir Robert Peel. President Hayes has shown himself a strong man, but the greatest trials of his strength are still to come. When Congress meets he will have to contend both with the resentment of the regular managers of his own party and with the hostility of the thorough-going Democrats, who will see their opportunity in the breach between the President and the party which raised him to power, as the Whigs in 1846 saw their opportunity in the breach between Sir Robert Peel and the Protectionist section of his followers. Supposing, however, that President Hayes, like

Peel, should fail, his attempt, like that of Peel, will have a significance which no momentary failure can annul. It announces the decline of the party system, and the advent, not immediate, perhaps, but still certain, of national government.

It is curious with what implicit faith we have all reposed upon party, as the normal, permanent, and only possible mode of carrying on a free constitution, disregarding not only the objections which reason obviously suggests to the system and the general evidences of its bad effects on politics and political character, but the facts which showed plainly enough that its foundations were giving way, and that, if this was the only basis of government, government was likely to be soon left without a basis.

Burke, in his "Thoughts on the Cause of the Present Discontent," has given at once his definition and his defense of party:

> "Party is a body of men united for promoting by their joint endeavors the national interest upon some particular principle in which they are all agreed. For my part, I find it impossible to conceive that any one believes in his own politics or thinks them to be of any weight who refuses to adopt the means of having them reduced into practice. It is the business of the speculative philosopher to mark the proper ends of government. It is the business of the politician, who is the philosopher in action, to find out proper means toward those ends, and to employ these with effect. Therefore every honorable connection will avow it as their first purpose to pursue every just method to put the men who hold their opinions into such a condition as may enable them to carry their common plans into execution with all the power and authority of the state. As this power is attached to certain situations, it is their duty to contend for these situations. Without a proscription of others they are bound to give to their own party the preference in all things; and by no means, for private considerations, to accept any offer of power in which the whole body is not included; nor to suffer themselves to be led or to be controlled or to be overbalanced, in office or in council, by those who contradict the very fundamental principles on which their party is formed, and even those upon which every fair connection must stand. Such a generous contention for power, on such manly and honorable maxims, will easily be distinguished from the mean and interested struggle for place and emolument. The very style of such persons will serve to discriminate them from those numberless impostors who have deluded the ignorant with professions incompatible with human practice, and have afterward incensed them by practices below the level of vulgar rectitude."

To form a rational and moral basis for party, to prevent party from sinking into faction, the party leader from becoming an "impostor," and the "generous contention for power" from degenerating into a "mean and interested struggle for place and emolument," there must be, as Burke says, a particular principle on which the members of the connection are agreed in desiring that government should be carried on. Failing such a principle, party, and the golden haze with which Burke, according to his manner, has surrounded it, vanish, and leave a faction or a void.

The principle must not be a moral principle, because this would imply an organized opposition to morality on the other side, and the permanent existence of an immoral party; two parties always in active existence being plainly essential to the working of the system. You cannot, for example, have a party of purity, because this would imply, as its correlative and complement, a party of corruption, and it would be a grotesque arrangement to devote half your citizens permanently to the service and advocacy of corruption in order to maintain the machinery of your government.

The principle must be one of expediency. Parties, in other words, must be divided by some question of policy, about which honest men may differ. And it must be a question of sufficient magnitude to transcend in importance all other questions; of sufficient importance to warrant a man of sense and a good citizen in surrendering for its sake his private judgment on all other political subjects to the guidance of the party leader and the exigencies of the party struggle, and in doing his utmost to exclude from the legislature and the public service all men, however honest, however able, however useful in general respects to the country, who do not agree with him on the vital point. We need not use the invidious term *proscription*; the thing will be the same.

Now, it is manifest, in the first place, that the occurrence of such questions is exceptional, and not normal; they can seldom arise in fact except with reference to some organic change in the constitution, such as the transfer of supreme power from the crown to Parliament, or the change in the character of Parliament itself, embodied in the English Reform Bill of 1832. American slavery was an issue of a different kind and of still more transcendent importance; but it was one lying quite beyond the pale of ordinary politics. In normal times the occupations of legislatures and governments will be matters of current administration, not one of which is likely to form an issue of sufficient importance to swallow up all the rest and form a rational ground for the division of the nation into two organized parties struggling each to place its leaders in exclusive possession of the powers of the state.

In the second place, questions of expediency, however important, do not last forever; in one way or other they are settled and disappear from the political scene. Slavery dies and is buried. Parliamentary reform is carried out with all its corollaries, and becomes a thing of the past. What is to follow? Another question of sufficient importance to warrant a division of the nation into parties must be found. But suppose no such question exists, are we to manufacture one? That is the work to which the wire-pullers devote themselves in democracies governed by party, but the results seem hardly to correspond to our notion of the adamantine basis on which the political edifice is to rest forever.

Some astronomers say that the moon once had an atmosphere, but that she has exhausted it, and that she shows us what our planet will be when, in the course of ages, its atmosphere also shall have been exhausted. The colonies, in this matter of party government, may furnish an indication of the same kind to the mother-country. In Canada, for example, while New World society was struggling to repel the intrusive elements of the old *régime* forced upon it by the imperial country, and to extort self-government, the parties, though not altogether edifying in their behavior or salutary in their influence upon popular character, were at least formed upon real lines. But the struggle ended with the abolition of the state Church and the secularization of the clergy reserves. Since that time there has been no real dividing line between the parties; they have ceased to be truly directed to public objects of any kind; their very names have become unintelligible. Politics under such a party system must inevitably sink at last into an "interested contest for place and emolument" carried on by "impostors who delude the ignorant with professions incompatible with human practice, and afterward incense them by practices below the level of vulgar rectitude." It is needless to say what effects an incessant war of intrigue, calumny, and corruption, carried on by such party leaders, with the aid of the sort of journalists who are willing to take their pay, must produce on the political character of a community, however naturally good, and well adapted for self-government. Nobody is to blame. The blame rests entirely on the system. Lord Elgin found fault with Canadian parties for being formed with reference to petty objects, not to great questions. It is singular that so acute a man should not have asked himself where the great questions were to be found. Were they to be manufactured or imported?

Nothing is more curious than the ingenuity with which new reasons are invented for old institutions when the original reasons have ceased to exist. The advocates of the party system in countries destitute of party questions, at a loss for rational grounds of defense, take a desperate dive into psychology, and affirm that all men are by natural tendency either Conservatives or Liberals, so that the division of every community into two parties is not merely a practical exigency of politics but a general law of humanity. In that case Nature must have been peculiarly kind to certain politicians who are furnished with a double set of tendencies enabling them to appear in both the parties at different periods of their career. It is hardly necessary to prove that the varieties of natural temperament are numberless, and are still further diversified by the influences of position, age, and fortune; and that to divide any nation into two organized parties according to their temperaments would be an undertaking far transcending in absurdity all the fancies of Laputa. Yet such philosophy probably helps to cast a halo over a contest of "impostors,"

the character and objects of which could not otherwise escape the most "vulgar" eye.

We have an example of the tendencies of the system in the Australian colonies, if Australian journals may be believed. Whatever land-questions or other questions of an organic kind or of permanent importance there were, having been settled, and no basis for parties left, party government it seems in those countries is weltering in cabal, senseless faction-fighting, and all the concomitant evils. The worst arts and the worst men inevitably acquire an increasing ascendency in public life. Changes of ministry, brought about for the most part by mere personal intrigue, are of constant occurrence. Government is almost as unstable as in Mexico, and though the mode in which the revolutions are effected is less violent, they are perhaps not much less injurious to the political character of the people, or less likely to produce a complete disintegration of authority in the end.

Imitation of England has led the political world a strange dance. The Chinese shipwrights, when desired to build a vessel in place of one which had been disabled by dry-rot, produced an exact copy, dry-rot and all. Montesquieu fancied that the grand secret of English liberty lay in the separation of the executive and the judicial power from the legislative. With their union in the same hands liberty would end. This theory found general acceptance; yet at the very time when Montesquieu made this profound observation, the legislature had in fact got into its hands the executive, which it appointed by the vote of its majority, and the judiciary, which was appointed by the executive. But the effect of the notion is visible in the provisions of the American Constitution; and the consequence is an occasional dead-lock, arising from a conflict between the legislature and the executive, as in the case of President Johnson, who was impeached to force him into harmony with Congress. Again, the House of Lords has been taken for a Senate, and the check imposed by its mature and deliberate wisdom on the rashness of the more popular House has been supposed to be the grand safeguard of British legislation. The House of Lords is not a Senate, nor a second Chamber, in the sense in which the term is practically employed by the architects of new constitutions. It is an estate of the realm: it is a privileged order having an interest of its own separate from that of the nation at large, and defending its own interests, which are necessarily those of privilege, and therefore of reaction, by resisting every measure of political change as long as it is safe to do so. Of its revising precipitate legislation in an impartial sense no instance can be found. But other nations try to reproduce it in the form of a second Chamber, and they find, one after another, that, compose your second Chamber and appoint its members as you will, the result is either a nullity or a collision between the two Houses, in which the more popular House will probably prevail.

In the same way it has been assumed that the English system of party and of cabinets, which are committees of party, is the vital principle of constitutional government. But party in England has been the instrument, probably the indispensable instrument, of a chronic revolution. By the action of the party which in its successive phases has borne the names of Puritan, Whig, and Liberal, the Tudor autocracy has been reduced to a limited, or rather a faineant, monarchy, and the Tory oligarchy, once intrenched in the rotten boroughs, has been replaced by a House of Commons elected on a more popular basis; supreme power, in other words, has been gradually transferred from the crown and the aristocracy to the representatives of the people. All this time there has been a real ground of division and a question of importance supreme enough to warrant allegiance to a party. But the process is now nearly complete. Other questions, of which the name Radical is the symbol, will probably emerge, and may again furnish grounds for the action of party. As it is, the lines between the aristocratic and democratic parties remain, though their outline is confused, and the democratic party is paralyzed for the time by the Conservative reaction, caused mainly by a vast influx of wealth. But we have an inkling at all events in the present state of things, even in England, of the time when the materials for party will be finally exhausted, and when we shall be obliged perforce to look out for some other mode of working constitutional government. Bayonets have their uses, but you cannot sit on them. Party has its use as the organ of a pacific revolution; but it will not supply the permanent basis of a national government.

Even in the course of the revolution, effected by means of party in England, as often as the movement has been temporarily suspended by accident or lassitude, the weakness of the system has appeared. Between the fall of Jacobitism and the advent of the French Revolution, when there was no great party question on foot, but the offices of state were still put up as the prizes of success in the struggle of parliamentary factions, you had half a century of chaotic intrigue and corruption, broken only by the short dictatorship of Chatham, whose own conduct, in the cabals which drove Walpole into the war with Spain, was an example, if not of place-hunting, of place-storming, of the most flagrant kind. The boasted efficiency of party, as a detector and exposer of abuses, was then proved to be little sustained by facts; it was seen, neither for the first nor for the last time, that two factions, whatever their mutual hatred, may virtually combine to preserve a privilege of plundering the community, which each hopes to exercise in its turn.

Not only is the usefulness of party as a political instrument closely connected with the peculiar circumstances of English history; it is closely connected also with the peculiar circumstances of an age of unscientific politics, of combinations formed upon class interests, of

little independence of mind, feeble reasonings, and strong passions. With the advance of political knowledge, of independent thought, and it must be added of public morality, allegiance to party grows less possible, party discipline loses its hold, the cohesion of party is broken up and refuses to be restored. The better a party is in point of intelligence, individual sense of responsibility, individual regard for the public good, the less submissive to the whip, and therefore the weaker, it becomes; a singular result of the only perfect system. What do we see in England now? On one side is a party weak to the verge of impotence, unable to act together even for one evening, to all appearances hopelessly excluded from power; and this because it is a party of opinion, of individual intelligence, of individual conscience, of individual desire to improve the condition of the people. On the other side is a party overwhelmingly strong, acting under perfect discipline, and likely to be for an indefinite time master of the state; and this because it is a party of interest, which always unites, while opinion inevitably divides.

Efforts are made on the Liberal side to compensate the weakness of mental independence as a basis of party union by increased stringency of organization. But these only bring more clearly to light the incompatibility of mental independence with the party system. In a recent number of this magazine we published a very graphic and interesting account of the political machinery used by the Liberal managers at Birmingham. We are not in a humor to quarrel with anything which in the present dearth of ability, especially of rising ability, in the House of Commons has helped to secure the election of Mr. Chamberlain. Nor do we overlook the fact that the spontaneous organization on the side of the Tories, in the shape of social connections and the tyrannical pressure they exert, is such that it can only be counterbalanced by artificial organization carried to a high pitch on the other side. But we must say that the use of such machinery does seem to involve a terrible sacrifice of those very habits of mental independence which it is the pride of Liberalism to promote. The absolute necessity of defending progress and the interests of the community at large against the despotism of a class alone reconciles us in any measure to the system. In the United States the masters of the party machines have everywhere taken the representation out of the hands of the people: you are practically not at liberty to vote for anybody but their nominees; and the Republican horse, to vanquish the Democratic stag, becomes absolutely the slave of its rider.

In the United States the opinion of the best judges, so far as we can gather it, is that the disorganization of the parties is increasing and is likely to increase. Nor is it possible to name any issues on which new parties can be formed. There is no question which, even supposing it to be of sufficient importance, would at all coincide with the existing lines; and a complete reconstruction of parties with a new

arrangement of the leaders and wire-pullers, irrespective of all personal connections, would be practically out of the question. Two alternatives will present themselves to the people: either a new mode of working constitutional government and maintaining the proper check on the executive must be found, or the President must be allowed to become something very like an elective dictator for a term of years.

The practice of setting up the offices of the executive as the prize of victory in a legislative contest carried on by the agency of party appears to be injurious alike to legislation and to executive government. It is injurious to legislation, because public men are constantly tempted to deal with legislative questions in the interest of their own ambition, for the purpose of paving their way to office, or strengthening their position there, not with a view to the proper objects of legislation; whence a number of unnecessary, premature, and dishonest measures. All the members of the Conservative party, before 1867, had recorded their opinions against a large extension of the franchise as tending to place political power in ignorant and irresponsible hands. They, then, to keep their party in office, and at the bidding of leaders who they knew had no other motive, themselves extended the franchise to the most ignorant and irresponsible part of the population, the populace of the towns. The practice is injurious to executive government, because it excludes or ejects from office the ablest and most trusted administrators on account of opinions respecting legislative questions which in no way affect administration. It wrongly unites, in short, two political functions which are perfectly distinct and which mutually suffer by being bound up with each other.

It is needless to dilate upon the relations of party, its machinery, its strategy, the press which serves it and expresses its passions, to public morality and the general interests of the state; the facts are always before our eyes. But experience of a colony or of some new country is needed to make one thoroughly sensible of the effects of this warfare upon the political character of the people, and of the extent to which it threatens to sap the very foundations of patriotism and of respect for lawful authority in their minds.

It is supposed that the hostile vigilance of party is the great safeguard against political corruption, and one which, if removed, it would be impossible to replace. But there are some countries at least in which the indiscriminate slander in which party constantly deals forms really a cloak of darkness for all corruption rather than a lantern for the detection of any; while its effect on the character of public men is to produce general lowness of tone and brazen indifference to accusations of every kind. The experiment has not yet been tried of legislating definitely against the corrupt use of legislative or executive power, which is a perfectly tangible crime (at least it is difficult to see why the sale of a vote in a legislative assembly, or of a government contract, is not as tangible a crime as the fraudulent breach of an or-

dinary trust), and of instituting a tribunal for the trial of offenders. And therefore we are still at liberty, at all events, to entertain the belief that the sight of a single politician suffering a felon's doom by the impartial and righteous judgment of a court of law, for the corrupt betrayal of his public trust, would have a more salutary effect than the interested and reckless denunciations of all the party orators and journalists in the world.

It is easy to see why, up to this time, party has been the law of politics; but it is not easy to see why, for the future, and as reason extends its sway over the political sphere and limits the reign of passion, party should be the law of politics more than of any other subject. Party, we mean, organized and permanent; such as the parties of the Guelfs and Ghibellines, of the Blacks and Whites, of the Caravats and Shanavests. On social and philanthropic questions, on questions and in movements of all kinds, people combine for a particular object, and the object having been gained they fall back into their ordinary associations. Why should they not do the same in politics, supposing politics to be a matter not of passion and ambition, but of reason and of the public good? This is the answer to the argument on the side of party that nothing can be carried without combination. It can hardly be necessary to meet the argument that political truth can only be hammered out by the constant collision of parties. With regard to all other subjects it is supposed that while free discussion is conducive to the discovery of the truth, party feeling and subserviency to party are most adverse to it. But people tacitly assume that they can have party without party feeling and the evils to which every one, when the question is distinctly proposed to him, admits that party feeling must lead.

Nor, again, need we dwell long on the argument that party is necessary in order to keep up an interest in human affairs. Human affairs, according to all present appearances, are likely to be interesting enough to keep the mind of man alive and to give birth to abundance of controversy (if that is the thing desired) for generations to come, without our forming artificial parties for the purpose of enabling ambitious men to obtain exclusive possession of the power of the state.

Party is no doubt indispensable to selfish interests, which by taking advantage of the balance of factions are enabled, to an almost indefinite extent, to compass their special objects at the expense of the community. It is indispensable to political sharpers who, without legislative powers or any sort of ability or inclination to serve the public in any honorable way, find subsistence in an element of passion and intrigue. To whom or to what else it is indispensable, no one has yet been able definitely to say.

Burke himself, the great apologist of party, was the great apostate from it. He called his apostasy fidelity to the Old Whigs; but the Old Whigs were in their graves, and the rhetorical turn given by him

to his secession did not alter the fact. In the case of his defense of party, as in many other cases, his fervid and unbridled imagination has erected a particular expedient, the necessity of a special occasion, into a universal and everlasting law. Before him, another man had shaken off party trammels apparently from the conviction of their radical inconsistency with the public interest. The life of Lord Shelburne is in this special respect a most important, as well as in all respects a most interesting, addition to political biography, and we shall see as it proceeds whether Shelburne is entitled to the credit of having tried to be a national statesman.

Our proposition, however, is this: that, let party, as a system of government, be good or evil, the materials for parties are nearly exhausted in the British colonies, and probably in the United States; that they are temporarily exhausted, and may one day be entirely exhausted, in England; while in other countries (in France and Germany, for instance) the sections and subsections of opinion are too numerous and the lines between them are too wavering to admit of the clear division into two parties absolutely essential to the working of the system, which, when there are three or four parties instead of two, becomes a quicksand of intrigue on which no government can be founded. Under these circumstances it is necessary, whether we will or not, to look out for some other foundation for constitutional government. The penalty of not doing so will be either confusion or the domination of some selfish and, because it is selfish, compact and all-powerful interest.

To determine what that foundation is to be, is probably a task reserved for better heads than ours. But perhaps the Swiss Constitution, in its general principles, may point the way. It suggests the regular election of the executive council by the legislature in place of a struggle of parties to determine which side of the House shall have the privilege of distributing the prizes among its leaders. The proper relations between the legislature and the executive might be preserved by a proper rotation of elections, with any such provisions as seemed expedient in the way of cumulative voting. The tenure of office would of course be limited; whether to the duration of the Parliament (which is the Swiss system) or to a term of years would be a question of detail, but the advantage of a continuous executive would be in favor of the latter plan. It does not seem that with this limitation the power of the members of the executive council would be too great, or that their responsibility would be unduly diminished; excess of authority, provided it be constituted in the interest of the whole nation and accountable to the nation in case of an abuse of power, is not the political danger which at present we have most reason to dread. Nor does it seem that, with, say, three elections occurring each year, the executive council could get much out of harmony with the legislature, or fail pretty adequately to represent the prevailing

sentiment of the legislature for the time being. But the executive under such a system would do its own work, and leave the legislature free to do the work of legislation. The special initiation of the Minister of Finance in financial matters would be preserved by the same sense of an obvious necessity which has established it. In the performance of purely administrative duties, all the members of the council might without difficulty agree, and their coöperation in their proper work might be perfect, notwithstanding possible differences of opinion about matters of legislation. Why should not a good Chancellor of the Exchequer act in harmony with a good Home Secretary notwithstanding a difference of opinion about the church establishment or the extension of the franchise? Why should the country be prevented by that difference from availing itself of the administrative capacity of both? And why should not each be free to vote as a member of the legislature, in accordance with his personal opinion? At present a cabinet has something of the character of a conspiracy, members often suppressing or even acting against their own opinions in order to present a united front to the enemy and to maintain their hold of power, from which no small calamities have flowed. It would not be difficult to point to instances of measures forced on a cabinet by some leading member, his colleagues acquiescing merely from fear of a break-up, and then carried through Parliament by the influence of government, though the sense both of the legislature and the cabinet was really the other way.

The tendency inherent in party government to supersede the national legislature by the party caucus has long been completely developed in the United States, where it may be said that in ordinary times the only real debates are those held in caucus, congressional legislation being simply a registration of the caucus decision, for which all members of the party, whether they agreed or dissented in the caucus, feel bound by party allegiance to record their votes in the House; just as the only real election is the nomination by the caucus of the party which has the majority, and which then collectively imposes its will on the constituency; so that measures and elections may be and often are carried by a minority but little exceeding one-fourth of the House or the constituency, as the case may be. The same tendency is rapidly developing itself in England; and it is evidently fatal to the genuine existence of parliamentary institutions.

So far as England is concerned, the institution of an executive regularly elected by the legislature at large in place of a cabinet formed of the leaders of a party majority would be substantially a return to the old form of government—the Privy Council. Parliament is now the sovereign power, and election by it would be equivalent to the ancient nomination by the crown. The mode of electing and confirming a Speaker shows how the forms of monarchy may be reconciled with the action of an elective institution.

However, be the proper substitute for party what it may, the thing here insisted on is that party is evidently in a state of decadence; that the causes of its decadence are not accidental or temporary, but inherent in its nature, which is that of an instrument of change, not that of a permanent principle of government; and that, consequently, sooner or later some other basis for government must be found. "You are sanguine," say objectors, "if you think you can carry on constitutional government without party." We trust not; for, if it is so, the end of constitutional government is at hand. The decline of party may fairly be said to present an urgent question: for the political observer to-day—to-morrow for the statesman.—*Macmillan's Magazine.*

SKETCH OF PROFESSOR JEVONS.

WILLIAM STANLEY JEVONS was born at Liverpool, in the year 1835. His father, Thomas Jevons, was an iron-merchant in that city; his mother was a daughter of William Roscoe, the well-known historian. She was a woman of great cultivation, the writer of hymns and poems which are to be found in general collections, and the editor of the "Sacred Offering." Young Jevons received his early education along with his cousin, Prof. Roscoe, at the High-School of the Mechanics' Institution, Liverpool, the head-master of which was, at that time, Dr. W. B. Hodgson, now Professor of Political Economy in the University of Edinburgh. At the age of sixteen he went to University College, London, and, during the two years he remained there, distinguished himself highly in the classes of mathematics and natural science. In 1853 he received, on the recommendation of Prof. Graham, the offer of an appointment as an assayer to the Australian Royal Mint at Sydney. He accepted this appointment, and, after having qualified himself by a course of assaying under Profs. Graham and Miller, he proceeded to Sydney, where he discharged the duties of the office for five years, devoting his leisure time to scientific investigations, particularly meteorology. He, however, resolved to leave this field of work and devote himself to the study of the higher sciences. Returning from Australia, he visited the United States in 1859, and, arriving at London, he at once resumed his studies in the University College, and won distinction in his various classes. In 1862 he graduated as M. A. with first-class honors, and the gold medal in the department of Logic, Philosophy, and Political Economy. Two years later he was elected Fellow of University College.

In 1863 he published his first important work on economical science, entitled "A Serious Fall in the Value of Gold ascertained, and its Social Effects set forth." He consented to take the position of tutor in Owens College in 1863, and in 1866 was elected to the chair of Logic and Political Economy in that institution. The year pre-

vious he had read to the British Association a paper containing the fundamental positions of his later work, "Theory of Political Economy." In 1865 appeared the treatise "On the Coal Question," dealing with the problem of the exhaustion of the English coal-mines, the calculations of which were adopted by Mr. Gladstone and Mr. Mill in their treatment of the subject. In 1869 appeared the small work, "Substitution of Similars the True Principle of Reasoning;" in 1870 he read a paper before the Royal Society "On the Mechanical Performance of Logical Inference;" and about this time he completed his well-known Logical Machine. In 1870 appeared the first edition of the "Elementary Lessons in Logic." The "Theory of Political Economy" was published in 1871; and the author's great work, "The Principles of Science," was issued in two volumes in 1874.

"The Principles of Science" is a comprehensive treatise on pure and applied logic, or on the formal theory of inference and the methods of scientific investigation. The first book resumes the author's previous researches in pure logic, and carries them a step further. All inference is regarded as essentially reasoning from similars to similars, affirming that what is true of one thing is true of its like. The rules of inference flowing from this general principle, and the symbolical notation employed to express all the forms of thought, are stated and exemplified with great fullness. The particular novelty introduced is the view of induction, which Prof. Jevons regards as merely the inverse process of deduction. Thus, in deduction, we have given to us certain relations among terms or notions, and by the application of the formal laws of thought we develop all the possible combinations which are consistent with given relations. In induction, on the other hand, the combinations of terms are given, and we require to reason backward to the possible relations from which they may result. Insisting strongly upon his view of inductive inference, Prof. Jevons is led to criticise and reject the ordinary accounts of the process. He declines to admit that inductive research necessarily involves the idea of causation, and assimilates it more nearly to the mathematical doctrine of probability. The chapter in which he expounds the philosophy of inductive inference is peculiarly valuable, and deserves more careful criticism than it has yet received. As final result we have the complete subordination of induction to deduction; all inductive research, according to Prof. Jevons, consisting of three steps—framing an hypothesis as to the general law, deductively inferring results from it, and comparing the inferred conclusions with real fact.

The subordinate points involved in this theory of induction, such as the principles of combination and the general method of calculating probabilities, are treated very elaborately. The problem of inverse probability, which is, in Prof. Jevons's view, identical with the problem of induction, receives most careful attention. Some attempts have recently been made to carry out one or two of the elaborate

logical computations shown to be necessary for the complete solution of the problem.

The remainder of the treatise is an exhaustive account of the methods of scientific investigation. What is most remarkable in this portion of the work is the combination of extensive and accurate knowledge of facts with perfect command of the most general principles. As a writer on scientific method, Prof. Jevons is fairly entitled to the credit of being a peer of predecessors so eminent as Herschel, Whewell, and Mill. He has given the fullest and best exposition of the methods actually employed by the greatest scientific workers, and has collected from all quarters a mass of most richly-varied illustration.

The concluding book of the treatise is a brief but pregnant essay on the results and limits of scientific method. The outcome of the author's careful analysis of induction, the essentially *probable* character of what are called natural laws, is applied as a corrective to the rash scientific generalizations indulged in by many writers, and to the equally rash deductions from them. At the present time his weighty remarks on the supposed contradiction between natural law and divine providence in any form are peculiarly deserving of attention.

Prof. Jevons published a volume, in 1875, entitled "Money, and the Mechanism of Exchange," forming part of "The International Scientific Series." It contains a lucid and admirably-written exposition of the nature and functions of money, the principles of circulation, the various forms of credit documents, and the elaborate mechanism (banks, check, and clearing systems) by which money exchanges are facilitated. Careful and complete historical notices are also given with regard to the various metallic currencies, modes of coinage, and regulations of issue, while technical matters, such as the qualities requisite for good metallic currency, the loss of weight in coins by usage, and the cost of keeping up the currency, receive due attention. His last publication was the little compendium of logic called "The Logic Primer," intended to give general readers some idea of this science.

In 1868 Prof. Jevons was appointed an Examiner in Political Economy in London University. In 1870 he was President of the Economic Section (Section E) of the British Association at its Liverpool meeting. In 1872 he was elected a Fellow of the Royal Society. In 1874 and 1875 he was an Examiner for the Moral Sciences Tripos at Cambridge. In the year 1876 the Senatus Academicus of Edinburgh University conferred upon him the honorary degree of LL. D.; and in the same year he was appointed Examiner in Logic and Moral Philosophy in London University. In March, 1876, Prof. Jevons announced his resignation of his professorship at Owens College; and in October, 1876, he entered upon the duties of the distinguished position to which he had been chosen, and which he now occupies, as Professor of Political Economy in University College, London.

CORRESPONDENCE.

"THE TIDES."

To the Editor of the Popular Science Monthly.

I HAVE read with a good deal of interest Prof. Schneider's article on "The Tides," in the July number of the MONTHLY. I was pleased with his method of approaching the problem, because it deals with the planetary bodies as we actually see them in motion, not demanding that effort of the imagination required in studying the problem simply as one of static equilibrium. He has succeeded in rendering tolerably intelligible from a new standpoint a subject which is perhaps left for the average reader in a somewhat unsatisfactory state in our popular works on astronomy and physical geography.

In proportion as he has done this portion of his work well, is any error of statement into which he may have been led liable to prove mischievous. This is my only excuse for venturing to offer any criticism on the work of one who has really done valuable service in presenting familiar truths in new aspects.

Nowhere is our author more clearly wrong than in his own criticism of the commonly-accepted theory of the causation of the tides. He admits, apparently, that the attraction of the moon, or of the sun, is capable of lifting into a tidal protuberance the waters that lie, in popular parlance, directly beneath them; but that the earth itself should be drawn away from the waters upon its opposite surface, he pronounces preposterously absurd. "It has been proved experimentally," he says, "that all bodies on the surface of the earth are heavier at midnight than at any other hour of the twenty-four." He cites no authority for this statement, which is simply inconsistent with the observed fact that at midnight, leaving out of account the influence of the moon, the tide is rising instead of falling. The state of the tide, however, as we shall perhaps have occasion to indicate hereafter, is not a trustworthy measure of the local variations in that gravitative force which manifests itself as weight. Unless, therefore, delicate experiments with the pendulum have actually demonstrated the existence and amount of such diurnal variations, we can only infer them from our knowledge of the forces which may produce them.

It is in his attempt to do this that our author falls into the fatal confusion of thought which leads him to pronounce absurd a theory which to the clear-sighted Newton was simply the truth. This confusion seems to arise wholly from a careless use of the term *weight* or gravity. On the side of the earth facing the sun, all particles of matter feel the attraction of the earth and that of the sun as forces acting in opposite directions. "The weight of a body situated at this point then will be diminished by precisely the amount of the sun's attractive force." Yes, if meanwhile the earth's centre remain stationary. But this is not the fact; the whole mass of the earth has simultaneously yielded to the solicitation of the same attraction. If these motions are equal, they can produce no change in weight, for weight is simply the force with which a body tends to approach the earth's centre, not simply the force with which it advances through space in the direction of that centre. Prof. Schneider himself points out the distinction, but proceeds immediately to ignore it in his reasoning. He says: "As the particles of the earth most remote from the sun feel its attraction *plus* that of the earth herself, they are drawn with greater force *toward the centre of the earth* than any other particles. Hence," he triumphantly asserts, "it cannot be true that the whole earth is drawn away from the waters, and that any tide is produced by the waters being left behind."

Having thus convincingly (?) shown the necessity for a more satisfactory hypothesis regarding the causation of the tides, he proceeds to offer one of his own. The first thing we remark, however, in examining this is that it embodies all that was contained in the old "absurd" hypothesis, while it complicates the problem by compelling us to consider not only the attraction of the sun or moon, but also the antagonizing force which prevents the earth from moving in the direction of the attracting body. It is true that by an ingenious misstatement of his own theory the writer avoids what to him seems paradoxical in that which he rejects. One of the tides—that on the side of the earth facing the disturbing body—he tells us, is produced by centripetal, the other by centrifugal force. In an explanatory paragraph he admits, although he does not distinctly state, what is the fact, viz., that in each case coinciding effects are produced by simultaneous variations in opposite directions of *both* these forces. Recognizing, however, the supreme value of directness and simplicity of statement in all popular expositions of scientific truth,

we are disposed to overlook inaccuracies such as these, lying merely on the surface. It is otherwise with anything that betrays confusion of thought in regard to the fundamental elements of the problem. This, it seems to me, the writer has done in ascribing to centrifugal force a primary place in the causation of tides. It is only as the waters upon the earth's surface have freedom of motion—are acted upon, therefore, as independent of the earth's mass—that tides are possible. On the other hand, only in so far as the waters take up by friction and cohesion of their particles the motion proper to the portion of the solid earth underlying them, will they acquire the increased tangential momentum which constitutes the so-called centrifugal force. When it is understood that the force in question operates only in this indirect manner, it becomes plain that it ought not to be classed with gravitation as a primary cause of the tides, but rather with the rotation of the earth as an important secondary factor, necessary to be studied in tracing out the actual operation of their real cause.

The new mode of explaining the observed phenomena is, however, on the whole, quite intelligible and satisfactory in its application to the solar tides. It requires a greater effort of the imagination to see exactly how the same principles operate in the causation of the lunar tides. It is easy to understand how centrifugal force will predominate on the side of the earth opposite the moon, and how the waters on the nearer side will tend to insphere themselves about the centre of gravity of the rotating system, a point only 2,687 miles from the earth's centre. There is some difficulty in taking on trust the statement that the earth will feel on the side facing the moon a centripetal force equal to the centrifugal force which is said to cause the tide on the opposite side, when we remember that the moon itself is a part of the rotating system, and must itself claim a share, however small, of the forces, centrifugal and centripetal, whose balancing equivalents are to be sought on the remote side of the earth. And it is far from clear to the tyro in mathematics why high tide should occur directly under the moon, where centrifugal force, acting in a direction away from the earth's centre, is but slight, while centripetal force, *acting in the opposite direction*, is at its maximum so far as it is dependent on proximity to the centre of rotation. Although the explanation of this latter apparent paradox is by no means difficult, it will certainly prove to many a fertile source of perplexity.

The interest I have myself taken in applying Prof. Schneider's hypothesis to the numerous practical problems which arise the moment we pass in our study from hypothetical tidal waves to the actual movement of the waters of existing oceans, has led me to jot down the above points in the way of friendly criticism. For the rest, I would rather listen to some abler critic.

A. B. LYONS, M. D.

DETROIT, *June* 27, 1877.

THE NEW IDEAS ABOUT SPACE.

To the Editor of the Popular Science Monthly.

DEAR SIR: The letter of Prof. G. B. Halsted, of Johns Hopkins University, in your number for July, 1877, in regard to the imaginary geometry of Gauss, Lobatchewsky, and Beltrami, brings to my mind the fact that there is no necessary truth in many things that we have regarded (at least we mathematicians) as necessary truths.

Sir George Airy investigated the conditions under which perpetual motion might exist (Cambridge "Philosophical Transactions," 1830, vol. iii., pp. 369–372).

Newton's notion of negative density ("Principia," book ii., sec. ii., prop. x.) is another case.

Laplace, in the "Mécanique Céleste," has indulged in a remarkable speculation as to what the laws of motion would have been if momentum, instead of varying simply as the velocity, had been a more complicated function of it.

These things seem to overturn current metaphysics, and that is about all the good in them. Yet Reid, in what he calls the Geometry of Visibles, chapter xli. of his "Inquiry," raised a question of like nature. Hamilton, as noticed by George Lewes ("Problems of Life and Mind," vol. ii., Appendix), has avoided any comment.

By reason of the superb contempt which this extraordinary man affected for mathematics, I presume he thought it beneath his notice. Your obedient servant,

LEWIS KENNON, M. D.

FORT BAYARD, NEW MEXICO, *July* 29, 1877.

THE WOODRUFF SCIENTIFIC EXPEDITION.

WE give below an important letter from Prof. Wilder, of Cornell University, on the Woodruff Scientific Expedition, and would call the attention of those interested to the assurances it contains concerning the opportunities for study and the facilities for original work which the expedition is expected to afford. Prof. Wilder is a member of the faculty of scientific instructors, and also one of the trustees of the expedition. The letter, as will be seen, is in response to our inquiries:

To the Editor of the Popular Science Monthly.

SIR: In answering your inquiry as to the nature and extent of scientific work to

be attempted on the Woodruff Expedition, and the facilities therefor, I must premise: first, that the published list of professors does not include several who are expected to conduct special departments of botany and zoölogy; second, that the faculty have had no official conference, so that I can speak only for myself.

My own duties will include—1. *General* lectures on the habits and structure of vertebrates. These will be nearly free from technicalities, so as to be intelligible to all. 2. *Special* instruction of those who may wish to go more deeply in certain directions; this by superintendence of dissections, and occasional lectures. 3. Instruction in methods of collecting, preparing, and preserving specimens. 4. Preparation of, and research upon, embryos, brains, hearts, and other soft parts, which are usually neglected by foreign collectors.

The students will provide their own dissecting instruments, cans, and preservatives; but, as stated on page 21 of the announcement, the management engages to furnish a library and apparatus for instruction.

I understand such requisite apparatus to include nets, dredges, and sounding arrangements, chemical and physical instruments, microscopes, diagrams, blackboards, stereopticon, and the means of preserving certain typical forms for illustration of lectures.

To insure the fulfillment of the promises made in the announcement, the trustees are to control the transfer of the fees to the director. The trustees are also members of the faculty, and their interests are therefore identified with those of the students.

From what I know or have heard of those concerned in the management of the expedition and the instruction, I feel confident that all possible facilities will be afforded for the acquisition of general information, and for the pursuit of special lines of investigation.

Respectfully yours,

BURT G. WILDER.

ITHACA, NEW YORK, *September* 1, 1877.

EDITOR'S TABLE.

CARPENTER ON SPIRITUALISM.

THE recent publication of Dr. Carpenter's little volume entitled "Mesmerism, Spiritualism, etc., Historically and Scientifically Considered," has given a renewed impulse to the discussion of this subject, and called out the strongest champions of the doctrines assailed. We have been accused of unfairness in not opening the columns of the MONTHLY for the spiritualists to present their side of the question; and so we print two replies to Dr. Carpenter, one English and the other American, by distinguished representatives of the spiritualist party. In THE POPULAR SCIENCE SUPPLEMENT, No. V., appears the answer to him made by Mr. A. R. Wallace, in the *Quarterly Journal of Science;* and in our present number the reader will find an original contribution, to the same purpose, by Dr. J. R. Buchanan, well known for the last thirty years as an eminent investigator and expositor of the so-called spiritualist phenomena. Dr. Buchanan is one of those who objected to our editorial course on this question as one-sided and unjust. Not liking this imputation, we offered him space in our pages to answer Dr. Carpenter. He accepted the offer, and we fulfill our promise. How far his article is to be regarded as a reply to the reasoning of Dr. Carpenter, or as convicting him of error, will probably be a contested question with different classes of readers; but he has, at all events, given us his very decided opinion of that gentleman, his book, and his backers. We fear, however, that the critic has forgotten, for once, that denunciatory epithets, however profuse and peppery, are not arguments. Dr. Buchanan seems to have vividly remembered all the hard hits that he and his coadjutors have received from scientific writers, and is bent upon using the opportunity to get even with them. This is laudable enough, within judicious limits; yet incontinence of vituperation is a symptom of weakness. Besides, something is due to self-respect; and if we thought Dr. Carpenter was the silly,

narrow-minded, muddle-headed, pretentious, and insolent imbecile that Dr. Buchanan intimates, we would try and find better occupation than troubling ourselves about his obsolete trash.

Dr. Buchanan opens his batteries against the materialists, but might he not as well have left this to some irate theologian? This polemical dash cannot be effective against Dr. Carpenter, who is certainly no materialist, either by his own avowal, by the tenor of his writings, or their common interpretation. On the contrary, he is a religious man, who has written copiously and cogently against materialism. The term materialism, skillfully used, is no doubt a good controversial weapon for popular effect, but in the hands of Dr. Buchanan it loses its edge, as he seems to regard all science which limits itself to the investigation of Nature in its ordinary aspects as materialistic.

We cannot here go into this controversy, but may briefly refer to what we regard as one of its primary issues. At the threshold of the subject we encounter the questions, What is Nature? What are the limits of its laws? and, What weight, or logical force, is to be allowed to the conception of the laws of Nature? When observation, experiment, and reason, have concurred in establishing a principle which may be always verified and found to be constant, what is the degree of firmness with which it is to be held? Science recognizes the laws of Nature as so fixed and fundamental that the well-trained mind must be under an overwhelming predisposition in regard to them. Hence, when marvelous stories are told of the violations of these laws, the tendency of such minds must be to put them aside as unworthy of attention. They cannot be entertained as against the demonstrated uniformities of the natural world. Much in regard to Nature is, of course, unknown; what we understand may be as but a few drops to the ocean in relation to what we do not understand; yet some things *are* known, and with so high a degree of certainty that we can rest in them with profound assurance that no future extension of knowledge can falsify them.

Dr. Carpenter maintains, and we think rightly, that there is a strong bias in scientific minds in favor of the inflexibleness of natural laws which the spiritualists do not share. His language is, that "it is quite legitimate for the inquirer to enter upon this study with that 'prepossession' in favor of the ascertained and universally admitted laws of Nature, which believers in spiritualism make it a reproach against men of science that they entertain." Both our critics resent this imputation upon "believers in spiritualism." Mr. Wallace declares it to be "unfounded and totally false;" and Dr. Buchanan affirms spiritualists to be "the foremost of all men in insisting on the universal inviolability of all the laws of Nature, extending their infrangible power not only over all physical phenomena, but throughout the equally extensive psychic realm."

It is obvious that Dr. Buchanan here uses terms to suit himself, as he gives to the phrase "laws of Nature" a meaning very different from its established scientific significance. In its scientific sense, the term "Nature" designates that sphere of phenomena, material and mental, of which we have constant experience, which is accessible to the human faculties, and which by its order becomes a subject of methodical knowledge; while the laws of Nature are the uniformities of action that are coextensive with this sphere. To this tract Dr. Buchanan annexes a "psychic realm," meaning thereby, not the common sphere of mind which is already embraced by the term "Nature," but a super-mundane, extra-material, preternatural, or spiritual world, above and beyond the sensuous order. This supernal region he claims to bring under the operation of the laws of Nature,

and therefore to make it a part of Nature, which we hold is simply to confuse all distinctions and confound the natural with the supernatural. Dr. Buchanan cannot do this in the name of science, for science itself has only come into existence by marking off the natural from the supernatural, and it belongs by its very essence and origin to one term of this contrasted relation. We cannot undo the great work of science, and cancel all that has been gained in the intellectual progress of mankind, by going back to primitive times when the natural and the supernatural were all mixed up, and nothing was known or suspected of such things as the laws of Nature. It was then believed that there exists an upper sphere inhabited by gods who interfered as they chose with earthly matters; the spiritualists now believe in a corresponding ghost-realm, inhabited by disembodied spirits, who have still the power of meddling with the course of terrestrial affairs.

This ultra-material realm, it is claimed, is manifested by material effects. But it is not by those effects which occur regularly and uniformly, and to which we give the name of laws, that it is the office of science to trace out. These are not attributed to spiritual agencies. The spirits are never alleged to be the causes of cohesion, refraction, digestion, gravity, or any of the matter-of-course operations that go on around us. They are only disclosed to us by striking, wonderful, exceptional, or miraculous manifestations; that is, the common order of Nature gets along without them, and they are only known by breaking through it. In Nature we see with our eyes; in the "psychic realm" men are said to see with the backs of their heads. In Nature tables remain at rest upon the floor forever unless some definite terrestrial force is applied to move them; in the "psychic realm" they travel about or rise to the ceiling without the intervention of any earthly cause. In Nature a bouquet will not pass through the woody barrier of a door, or the resisting masonry of a wall; in the "psychic realm" "a large bunch of hollyhocks, asters, laurels, and other shrubs and flowers," is mysteriously spirited into a house without coming through the usual openings in the usual way by which material bodies are transferred. In Nature, if a man unguardedly loses his balance in a window, he falls to the earth; but in the "psychic realm" Mr. Home "floats in the air by moonlight out of one window and in at another at a height of seventy feet from the ground." In Nature, if we wish to go to a house, we must walk there or get a conveyance to be carried, and then can only get inside by the opening of some passage of entrance; but in the "psychic realm" buxom Mrs. Guppy "sails through the air all the way from Highbury Park to Lamb's Conduit Street, and is brought by invisible agency into a room of which the doors and windows were closed and fastened, coming plump down in the midst of a circle of eleven persons who were sitting in the dark shoulder to shoulder."

Can those who believe these things be said to maintain the laws of Nature? Certainly not, in any such sense as that which science affirms. The spiritualists say that these apparently miraculous effects are not really miraculous, but are simply the consequences of higher laws of Nature by which the lower ordinances of the material sphere are overcome. But it is clear that before the man of science can accept such astounding propositions he must give to the winds all those laws of the natural world which he has been accustomed to regard as of demonstrated constancy. In life, by all his resources, the most gifted man cannot suspend the operation of gravity upon a single particle of matter by an infinitesimal fraction. But when he dies we are taught that his ghost can come back, and suspend

the action of gravity, in a way to excite the astonishment of whole circles. And this miraculous prerogative, we are told, is, itself, but an exemplification of natural law. But, assuming the truth of the spiritualist's view, we have simply come to an end of natural law. If the wonders alleged be true, where is the basis of trust in the regular course of Nature? If the uniformities of phenomena that science assumes to have discovered can, as a matter of fact, be disturbed by the capricious incursions of unseen beings, then there are no such uniformities; and the conception of law, instead of being the most fundamental conviction of the scientific mind, is an illusion to be abandoned. Anxiety about the constancy of these laws is, however, the last thing that troubles scientific men, and their repose of mind upon this subject sufficiently accounts for their general indifference to the claims of spiritualism.

INDICATIONS OF PROGRESS.

Our readers will well remember the row occasioned last year when Prof. Huxley said that the evidence of the truth of evolution must be accepted as demonstrative. We mark with interest the decisive indications that are accumulating in confirmation of Prof. Huxley's position. Another President of the British Association for the Advancement of Science has spoken upon the subject, under the responsibilities of his distinguished position, and in entire corroboration of the avowals of former presidents of that body for the last dozen years in relation to this question. His indorsement of evolutionary doctrine is emphatic and unqualified. Prof. Allen Thomson has been well known as an eminent cultivator of biology; but he comes forward now as a new authority, and will be listened to without the prejudice which attaches to the names of those men who have been in the thick of the fight for the last twenty years. The topic of the presidential address is the "Development of the Forms of Animal Life," and we here quote the opening passages, describing the remarkable change in the manner of viewing biological questions which has taken place during the last half-century. President Thomson says:

"In the three earlier decades of this century it was the common belief, in this country at least, shared by men of science as well as by the larger body of persons who had given no special attention to the subject, that the various forms of plants and animals recognized by naturalists in their systematic arrangements of genera and species were permanently fixed and unalterable; that they were not subject to greater changes than might occur as occasional variations, and that such was the tendency to the maintenance of uniformity in their specific characters that, when varieties did arise, there was a natural disposition to the return, in the course of succeeding generations, to the fixed form and nature supposed to belong to the parental stock; and it was also a necessary part of this view of the permanency of species that each was considered to have been originally produced from an individual having the exact form which its descendants ever afterward retained. To this scientific dogma was further added the quasi-religious view that, in the exercise of infinite wisdom and goodness, the Creator, when he called the successive species of plants and animals into existence, conferred upon each precisely the organization and the properties adapting it best for the kind of life for which it was designed in the general scheme of creation. This was the older doctrine of 'Direct Creation,' of 'Teleological Relation,' and of 'Final Causes;' and those only who have known the firm hold which such views had over the public mind in past times can understand the almost unqualified approbation with which the reasoning on these questions in writings like the 'Bridgewater Treatises' (not to mention older books on natural theology) was received in their time, as well as the very opposite feelings excited by every work which presented a different view of the plan of creation.

"On the Continent of Europe, it is true, some bold speculators, such as Goethe, Oken, Lamarck, and Geoffroy St.-Hilaire, had in the end of the last and commence-

ment of this century broached the doctrine that there is in living beings a continuous series of gradations as well as a consistent and general plan of organization; and that the creation, therefore, or origin of the different forms of plants and animals must have been the result of a gradual process of development or of derivation one from another, the whole standing connected together in certain causal relations. But in Britain such views, though known and not altogether repulsive to a few, obtained little favor, and, by some strange process of reasoning, were looked upon by the great majority as little short of impious questionings of the supreme power of the Almighty.

"How different is the position of matters in this respect in our day!—when the cautious naturalist receives and adopts with the greatest reserve the statement of fixed and permanent specific characters as belonging to the different forms of organized beings, and is fully persuaded of the constant tendency to variation which all species show even in the present condition of the earth, and of the still greater liability to change which must have existed in the earlier periods of its formation—when the belief prevails that so far from being the direct product of distinct acts of creation, the various forms of plants and animals have been gradually evolved in a slow gradation of increasing complexity; and when it is recognized by a large majority of naturalists that the explanation of this wonderful relation of connection between previously-existing and later forms is to be found in the constant tendency to variation during development and growth, and the perpetuation of such variations by hereditary transmission through successive generations in the long but incalculable lapse of the earth's natural mutations. These, as you must all be aware, are in their essential features the views now known as Darwinism, which were first simultaneously brought forward by Wallace and Darwin in 1858, and which, after being more fully elaborated in the works of the latter and ably supported by the former, secured, in the incredibly short space of ten or twelve years, the general approval of a large portion of the scientific world. The change of opinion is, in fact, now such that there are few scientific works on natural history, whether of a special or more general character, in which the relation which the facts of science bear to the newer doctrines is not carefully pointed out; that, with the general public too, the words 'Evolution' and 'Development' have ceased to excite the feelings, amounting almost to horror, which they at first produced in the minds of those to whom they were equally unfamiliar and suspicious; and that even in popular literature and ephemeral effusions direct or metaphorical illustrations are drawn in such terms of the Darwinian theory as 'struggle for existence,' 'natural selection,' 'survival of the fittest,' 'heredity,' 'atavism,' and the like.

"It cannot be doubted that in this country, as on the Continent, the influence of authority had much to do with the persistence of the older teleological views; and, as has been well remarked by Haeckel, one of the ablest and keenest supporters of the modern doctrine, the combined influence more especially of the opinions held by three of the greatest naturalists and biologists who have ever lived, viz., Linnæus, Haller, and Cuvier, men unsurpassed in the learning of their time, and the authors of important discoveries in a wide range of biological science, was decidedly adverse to the free current of speculative thought upon the more general doctrines of biology. And if it were warrantable to attribute so great a change of opinion as that to which I have adverted as occurring in my own time to the influence of any single intellect, it must be admitted that it is justly due to the vast range and accuracy of his knowledge of scientific facts, the quick appreciation of their mutual interdependence, and above all the unexampled clearness and candor in statement of Charles Darwin.

"But while we readily acknowledge the large share which Darwin has had in guiding scientific thought into the newer tracts of biological doctrine, we shall also be disposed to allow that the slow and difficult process of emancipation from the thralldom of dogmatic opinion in regard to a system of creation, and the adoption of large and independent views more consistent with observation, reason, philosophy, and religion, has only been possible under the effect of the general progress of scientific knowledge and the acquisition of sounder methods of applying its principles to the explanation of natural phenomena."

President Thomson's address concludes with the following words: "I consider it impossible, therefore, for any one to be a faithful student of embryology, in the present state of science, without at the same time becoming an evolutionist. There may still be many

difficulties, some inconsistencies, and much to learn, and there may remain beyond much which we shall never know; but I cannot conceive any doctrine professing to bring the phenomena of embryonic development within a general law which is not, like the theory of Darwin, consistent with their fundamental identity, their endless variability, their subjugation to varying external influences and conditions, and with the possibility of the transmission of the vital conditions and properties, with all their variations, from individual to individual, and, in the long lapse of ages, from race to race.

"I regard it, therefore, as no exaggerated representation of the present state of our knowledge to say that the ontogenetic development of the individual in the higher animals repeats in its more general character, and in many of its specific phenomena, the phylogenetic development of the race. If we admit the progressive nature of the changes of development, their similarity in different groups, and their common characters in all animals, nay, even in some respects in both plants and animals, we can scarcely refuse to recognize the possibility of continuous derivation in the history of their origin; and however far we may be, by reason of the imperfection of our knowledge of paleontology, comparative anatomy, and embryology, from realizing the precise nature of the chain of connection by which the actual descent has taken place, still there can be little doubt remaining in the mind of any unprejudiced student of embryology that it is only by the employment of such an hypothesis as that of evolution that further investigation in these several departments will be promoted so as to bring us to a fuller comprehension of the most general law which regulates the adaptation of structure to function in the universe."

THE DECLINE OF PARTIES.

We print the able and suggestive essay of Prof. Goldwin Smith on "The Decline of Party Government." He opens an interesting question, which, in one shape or another, is bound to force itself more and more upon thinking people. The customary short logic of the case is that we cannot have government without politics, and we cannot have politics without partisanship; this is, therefore, a necessary thing, which must hold the same ascendency in the future that it has held in the past, so that all ideas of doing without it are futile, and all inquiries respecting its decline superfluous. We do not suppose that political parties are to cease, or that partisans have the slightest occasion for anxiety respecting their continuance; but we do not believe that the future is to repeat the past in this matter. The progress and diffusion of science, the formation of scientific habits of thought, and an increasing faculty of observing and reasoning directly upon the facts of life, are going to interfere materially with the ideas and interests of politics. Thus far politics has been a blind and bungling art, necessary indeed, but so crude, loose, and wasteful in its practices, and so much a matter of rule-of-thumb, and transient experience, and the manipulation of men, that all idea of far-reaching principles in the political sphere is currently scouted. Yet this is not the region of chaos, and there are laws in political phenomena, deeper than legislative enactments. These are to be gradually worked out into scientific expression, and in proportion as this is done political partisanship must undergo important modification. It may be, as Prof. Smith assumes, that partisanship must decline for lack of serious issues upon which multitudes of men can be kept in proper antagonism. But we calculate upon a growing dissatisfaction with the methods by which the most valid political

questions are dealt with. The assertion of principles and the advocacy of measures must continue to be indispensable, and there cannot fail to be differences of opinion; but partisan ethics demands denial as well as affirmation, and denial as a matter of policy. It provides for opposition, and of course dreads acquiescence and agreement. As a work of dealing with serious questions, this policy cannot continue to command respect. Indeed, there is already a growing disgust in the community at the emptiness and futility and humbug of political partisanship. Men of honest purposes and fair discrimination will not go to the polls to vote unless overborne and swept along by a factitious excitement. We are told that good men should attend primary meetings, so as to rescue politics from the corrupt hands into which it has fallen. But it is a grave question whether it has not fallen into such hands by the necessary laws of partisanship. What is the chance of a plain, honest man, accustomed to open dealing, in a caucus or convention against the skilled intriguers, the practised wire-pullers, and the disciplined managers, who fill the air with their cries of "reform," and outdo everybody in their zeal to purify politics? The stealthy, long-headed calculator beats the man of inexperience at every tack and turn; and party politics is peculiarly the field where craft, manœuvre, and strategy, have their unhindered way. This is being increasingly recognized, and there is coming with it a deepening distrust of partisan agency. To get everything decent out of politics as quickly as possible is now the open demand. Courts, schools, prisons—all the important agencies of society—must, it is admitted, be taken out of politics, if their purity and efficiency are to be maintained; and even the chief office-holder of the nation heads a crusade to get all the office-holders of the country out of politics. Citizens may be expected to imitate this good example, and more and more get out of politics themselves.

FURTHER ASTRONOMICAL DISCOVERIES.

The luck of successful research seems now with the astronomers. Last month we announced the brilliant discovery of oxygen in the atmosphere of the sun by Prof. Henry Draper; and we have now to chronicle the equally brilliant discovery of two satellites of Mars by Prof. Asaph Hall, of the Naval Observatory at Washington; and also of a third moon of Mars discovered ten days later by Profs. Henry Draper and E. H. Holden at the private observatory of the Drapers, at Hastings-on-the-Hudson. We publish an interesting article, by Prof. Daniel Kirkwood, on "Mars and his Satellites," giving an account of the growth of our knowledge of the planet and the particulars of Prof. Hall's discovery of his moons.

As Prof. Kirkwood remarks, the question whether Mars had a satellite, which has now been so remarkably resolved, has long interested astronomers. How they have regarded it may be illustrated by the following passage from the third edition of Mr. Chambers's admirable "Hand-book of Descriptive Astronomy," published this year:

> "As far as we know, Mars possesses no satellite, though analogy does not forbid, but rather, on the contrary, leads us to infer the existence of one; and its never having been seen, in this case at least, proves nothing. The second satellite of Jupiter is only $\frac{1}{43}$ of the diameter of the primary, and a satellite $\frac{1}{43}$ of the diameter of Mars would be less than one hundred miles in diameter, and therefore of a size barely within the reach of our largest telescopes, allowing nothing for its possibly close proximity to the planet. The fact that one of the satellites of Saturn was only discovered a few years ago renders the discovery of a satellite of Mars by no means so great an improbability as might be imagined."

LITERARY NOTICES.

Experimental Science Series for Beginners. Light: a Series of Simple, Entertaining, and Inexpensive Experiments in the Phenomena of Light, for the Use of Students of every Age. By Alfred M. Mayer and Charles Barnard. New York: D. Appleton & Co. Pp. 112. Price, $1.

The expensiveness of apparatus has long been felt as a formidable difficulty in the effort to make scientific education popular and practicable. There is double hindrance here; the instruments of experiment are so costly that they cannot be procured for common use, and because of this expensiveness they have to be kept in careful charge, so that ordinary pupils cannot use them, and must content themselves merely to look on and see others work. But what is wanted indispensably is, that all the students shall be themselves put to work; shall be set to making experiments, and observing and proving things for themselves. The obstacles to such a course have hitherto been so great and so general that pupils have had but little chance to cultivate manipulation; and but few schools, in fact, have been able to procure the instruments requisite for demonstration on the part of the teacher. To remedy these difficulties and point out not only how scientific apparatus for physical experiments can be cheaply made, but how much the pupil can do to help himself in the matter, Prof. Mayer, of the Stevens Polytechnic Institute, has undertaken a series of little books, of which the first is now published. His choice of a subject to begin with is most fortunate. The phenomena of light are at once familiar and attractive, are always available, and admit of appliances for illustration of the most simplified and inexpensive character. We give ample illustrations of this in another article of the Monthly, from which the reader will see how much can be done in the way of careful experimental work for the illustration of the principles of optics, with but a small outlay of money and but little trouble.

The authors say in the preface: "It is believed that this book will occupy a place hitherto unfilled in scientific literature. It is specially prepared for the boy or girl student and for the teacher who has no apparatus, and who wishes his pupils to become experimenters, strict reasoners, and exact observers. Nearly all the experiments described are new, and all have been thoroughly tested. The materials employed are of the cheapest and most common description, and all the experiments may be performed at an expense of less than fifteen dollars. The apparatus is at the same time suitable for regular and daily use in both the home and school, and with care should last for years."

It is proper to add, in explanation of the joint authorship of the work, that Prof. Mayer has been long busy in inventing simple and cheap apparatus to help teachers and pupils in the art of experimenting; but, being greatly occupied with his professional duties, he made an arrangement with Mr. Charles Barnard to assist him in preparing his results for the press. All the contrivances and inventions for illustrating experiments belong to Prof. Mayer; Mr. Barnard has attended to the detail in the execution of the book, while Prof. Mayer has maintained a close supervision of the work.

Report of the Commissioner of Fish and Fisheries. Part III., for 1873–'74 and 1874–'75. Washington: Government Printing-Office.

In this report Prof. Baird gives the results thus far obtained in the inquiry into the decrease of food-fishes, and the efforts to protect and propagate them in American waters. The work in which the commission is engaged is an important one; it has been pushed with vigor, and with results which upon the whole are encouraging. The extent to which fish can be made to contribute to the food-supply is not generally appreciated. It is not alone the fisheries of the coasts and the Great Lakes that may be made to have value, but every mile of river and creek, and every pond and even ditch, may, with proper management, be made to contribute toward supporting a stock of fish. They manage these things better in China, and have carried pisciculture to an extent unknown among Western nations.

Many of the indigenous game-fish decline to adapt themselves to the changed

conditions resulting from civilization—they gradually disappear from the streams, and even if they did not are often greedy, carnivorous savages, who effectually bar a great increase of numbers, especially in small waters They must be replaced by species that take more kindly to cultivation—that may be domesticated. The trout seems well adapted to pond-culture, and its merits are well known. Prof. Baird also ranks the European carp very highly in this connection, and believes that for propagation in ponds and sluggish waters, both North and South, it will excel all others. Its good qualities are: fecundity and adaptability to the processes of artificial propagation; hardiness, rapid growth, and ability to populate waters to their greatest extent; harmlessness in relation to other fishes, living largely on a vegetable diet; and good table qualities.

The volume is largely occupied by supplementary papers of unequal value: accounts of the fish-industries of other ages and countries; reports of the special efforts to transport fish, lobsters, etc., to and from California, and to Europe; and an appendix devoted to the natural history of the subject. A systematic list of food-fishes, with descriptions and some account of their range, seasons, etc., would be a valuable and much-needed contribution to common knowledge. We hope it will be possible for Prof. Baird to carry out his partial promise to issue such a work in such a way that it will be obtainable by the general public.

Ancient Society: or, Researches in the Lines of Human Progress from Savagery through Barbarism to Civilization. By Lewis H. Morgan, LL. D. New York: Henry Holt & Co., 1877. Pp. 560. Price, $4.

Many of the obscure problems of ethnology are here analyzed and discussed with a wealth of learning which renders the work a valuable one for both the student and general reader. In the opening paragraph the author affirms the great antiquity of mankind upon the earth, and proceeds to illustrate the extreme rudeness of their early condition and the gradual evolution of their mental and moral powers through the slow accumulations of experience. The facts presented throughout the work show that the progress of mankind has been from the bottom of the scale, and that "the theory of human degradation, to explain the existence of savages and barbarians, is no longer tenable." It is shown that human progress has been essentially continuous, and that there is a common principle of intelligence in the savage, the barbarian, and the civilized man. As a consequence of this, the same results have appeared at all times and in all areas under the same ethnical conditions. "The roots of modern institutions," the author observes, "are planted in the period of barbarism, into which their germs were transmitted from the previous period of savagery. They have had a lineal descent through the ages with the streams of the blood, as well as a logical development."

The subject is considered by the author under these four heads: 1. Growth of Intelligence through Inventions and Discoveries; 2. Growth of the Idea of Government; 3. Growth of the Idea of the Family; 4. Growth of the Idea of Property.

In the discussion of each of these the reader is made familiar with the successive phases of culture which society has passed through in the course of its development. These phases are, as defined by the author, savagery, barbarism, and civilization, constituting three grand ethnical periods in the progress of mankind. Savagery, the term applied to the lowest status, extends from the period in which mankind were without arts or definite social organizations to that in which they had attained something of both. With the close of the period of savagery that of barbarism begins. At this period the art of making pottery had been developed; the bow and arrow, and implements of flint and stone, were in use. The ethnical period of barbarism is subdivided, as is that of savagery, into three stages, representing characteristic phases of culture. It began with the simple arts referred to, and ends with the invention of a phonetic alphabet and the use of writing in literary composition. In this stage of culture are placed the Grecian tribes of the time of Homer, and the Germanic tribes of the time of Cæsar. Civilization begins with the close of barbarism. It will not be inferred that the transition from one status

of society to another has been sharp or sudden. "Time has been an essential element in the formation of these strata."

The various lines along which development has taken place are thus summarized: 1. Subsistence; 2. Government; 3. Language; 4. The Family; 5. Religion; 6. Home-Life and Architecture; 7. Property. In the author's plan each of these lines is followed in detail, and the characteristic features of each in the successive stages of culture are presented in their order. Thus *subsistence* is shown to have been at first upon fruits and roots. Next in order came fish, then farinaceous substances; later, meat and milk; and lastly arose agriculture. It is obvious that food and the methods of procuring and preparing it have direct relation to culture, so that the status of a primitive people may be determined very nearly by that standard.

The author's elaborate discussion of the genesis of the family will be read with close attention, and will doubtless excite criticism. We can only in the briefest manner state without comment some of the aspects and forms of the primitive family as presented in the work. The lowest status of society is characterized by promiscuous intercourse. The next stage was intermarriage of brothers and sisters. Out of this arose the consanguineous family, or family representing consanguinity and affinity, giving rise finally to the organization of the family on the basis of sex. In this a check was given to the intermarriage of brothers and sisters, and following this occurred marriage between single pairs. A higher stage was the patriarchal family arising from pastoral life. Lastly arose the monogamian family, in which paternity of children is assured, with ownership of property, and lineal descent.

Throughout the work it is made apparent that the earliest steps in progress were taken with difficulty, and required a long period of time. But changes became more rapid as society advanced. If 100,000 years be assumed as the period of man's existence on earth, 60,000 years, on the theory of progressive development, must be assigned to savagery, 20,000 years to the lower stage of barbarism, 15,000 years to the middle and upper stages of barbarism, leaving but 5,000 years for the period of civilization. It would thus appear that during three-fifths of the whole human period man was scarcely more than a child. Whatever changes of fact or of conclusion future inquiries may render necessary in the present work, it will remain a monument of the painstaking labor of the author.

Principles of Theoretical Chemistry, with Special Reference to the Constitution of Chemical Compounds. By Ira Remsen, M. D., Ph. D., Professor of Chemistry in the Johns Hopkins University. Philadelphia: Henry C. Lea, 1877. Pp. 231. Price, $1.25.

This is a contribution to chemical literature of special fitness and importance at the present time, when the science is passing into a new stage. Prof. Remsen devotes himself to the theoretical aspects of what is called the new chemistry, which he treats with discrimination, presenting its claims with clearness and weighing its defects with fairness. He aims to show exactly upon what basis our present conceptions of chemical constitution rest. The need of a sifting discussion of the subject is assumed to rest upon the fact that the more recent views, be they good or bad, are held by nearly all the working chemists of the day. In regard to the execution and purposes of his book, the author remarks in his preface: "The subject is, of course, not exhausted; many things have purposely been left out, either because they have not yet reached such a stage of development as to entitle them to a place among the fundamental principles, or because it was thought better to emphasize more strongly those principles which are treated. Should the reader miss anything which he expected to find, he will please carefully consider whether the grounds referred to are a sufficient excuse for the omission. The imperfections that will be noticed are, partly at least, due to the imperfection of our knowledge on some of the subjects discussed. For instance, it seems to be impossible for us at present to treat the subject of valence in such a way as to lead to satisfactory results, mainly for the reason that we know so little in regard to it. Whatever view of this property one may take, he will find some difficulties which he cannot surmount."

Physiological Æsthetics. By Grant Allen, B. A. Pp. 283. New York: D. Appleton & Co. Price, $1.50.

Prof. Allen dedicates this book to Herbert Spencer as "the greatest of living philosophers," and, as might be expected from this, he treats his subject from the point of view of Spencer's philosophy and the law of evolution. This is only another exemplification of the power of a great principle, when newly introduced into thought, of modifying old beliefs and methods of study. Mr. Bain took up the investigation of the human mind more closely from the physiological side than had been before attempted in any general exposition; but he could not link psychology to physiology without bringing it more completely into the current of scientific progress. Hence, when the doctrine of evolution was accepted, physiology underwent a philosophical change which was so powerfully felt in psychology that Prof. Bain had to revise his methodical works to bring them into harmony with it. As æsthetics is occupied with a certain order of human feelings, its roots must be found in physiology, and Prof. Allen's book is an attempt to trace out the connection. We shall review this work more fully in the future, but may here remark that it has been received with great interest and very cordial approval abroad. There are various opinions as to the completeness of his analysis, and the sufficiency of some of his reasonings, but it is agreed that he has opened the subject in a broad aspect, and in a direction that must be pursued by future thinkers. The London *Examiner* thus refers to the work in the opening of its review:

"Among the branches of human activity which the growing science of physiology is destined to illuminate, the fine arts certainly have a place. In proof of this we need refer only to the work of a single living physiologist, H. Helmholtz. Of the importance of this thinker's physiological contributions to the theory of musical art it is unnecessary to speak. It may not be so widely known that this same physiologist has recently published an instructive essay, illustrating the bearing of optical science on the art of painting. This invasion of the region of æsthetics by natural science will be regarded as an evil by all those who suppose that this territory should be infolded in a mist of super-subtile metaphysical fancy. To those, however, who ask for a clear and well-defining daylight in all domains of inquiry, the new direction of physiological labor will be welcome. If anything is likely to supply a firm objective basis for æsthetic rules it is physiological science. Mr. Grant Allen distinctly recognizes this, and his volume is a valuable attempt to add to the physiological foundations of art.

"Our author begins with a timely protest against the unscientific idea, apparently countenanced by Mr. Ruskin, that the pleasures of art are not susceptible of exact explanation. He holds that æsthetic enjoyments, like all other pleasures, may be brought under simple principles or laws of nervous action. Moreover, he goes further, and, by help of the new science of organic evolution, seeks to explain how it is that our nervous system has become so constituted as to respond in a pleasurable or painful manner to the various sensory stimuli. In this way he hopes to arrive at a complete answer to the question regarded as insoluble by Mr. Ruskin, 'Why do we receive pleasure from some forms and colors, and not from others?'

"The physiological method of study cannot as yet be safely carried into the discussion of art-effects beyond the simple sensations of tone, color, etc. The physiological conditions of the more complex delights of intellect and emotion are not as yet accessible. It is a question, indeed, whether as yet the physiological method is adequate to explaining all the æsthetic pleasure of tone and color, and their combinations. This, however, is the task which Mr. Allen sets before himself. He devotes the greater part of his space to the elementary pleasures of art, illustrating these, as is fitting, by a general review of the phenomena of pleasure and pain in the lower bodily regions and in the various senses. Following most recent writers on the subject, he connects pain with the destructive or injurious action of an organ, pleasure with the normal action corresponding to the amount of energy stored up at the time."

Bulletin of the Geological and Geographical Survey of the Territories (Hayden's). Volume III., No. 1. Pp. 185. With Plates. Washington: Government Printing-Office.

In this number of the "Bulletin" are contained twelve papers, mostly on subjects anthropological and entomological. Among them is one by the Rev. M. Eells, on the Twana Indians of the Skokomish Reservation, in Washington Territory. This is an instructive account of the condition of a tribe of Indians in the transition state from savagism to semi-civilization.

Recent Progress in Sanitary Science. By A. R. Leeds. Pp. 22. Salem: printed at the Salem press.

The progress made in sanitary science during recent years consists, according to

Prof. Leeds, first, in an increased knowledge of what constitutes clean air, clean water, clean food, and clean environments, on the one hand, and on the other hand what constitutes filth in air, filth in water, filth in food, and filth in our environments, whether it be filth mineral, vegetable, or animal; and, secondly, in a better knowledge of the means of preserving cleanliness and repressing filthiness.

Bulletin of the Geological and Geographical Survey of the Territories (Hayden's). Vol. III., No. 3. Pp. 105. With Plates. Washington: Government Printing-Office.

Besides a series of five paleontological papers by Dr. C. A. White, this number of the "Bulletin" contains a brief essay by E. A. Barber on the "Utah Dialects." Also, one by P. Schumacher on "Method of Making Stone Implements." There is a paper by Dr. Coues on "Insectivorous Mammals;" one by Lieutenant McCauley on the "Ornithology of the Red River of Texas;" a "Catalogue of Land and Fresh-Water Shells," by S. Aughey, Ph. D.; finally, "Notes on the Geographical Work of the Survey," by A. D. Wilson.

Annual Report of the Massachusetts State Board of Health. Pp. 520. Boston: A. J. Wright, State Printer.

The Massachusetts health reports, of which this volume is the eighth, form a series of public documents hardly equaled for the wealth of important information which they contain. The "Special Reports" on sanitary subjects comprised in the present volume are seven in number, and treat of "Pollution of Streams, Dispersal of Sewage, etc.;" "Sewerage;" "Sanitary Condition of Lynn;" "Registration of Deaths and Diseases;" "Growth of Children;" "Disease of the Mind;" and "Health of Towns." It is only by unceasing iteration of the lesson that filth is the great cause of disease, that the local authorities of towns and cities can be aroused to a sense of the danger of allowing insanitary conditions to persist. This lesson is inculcated with much force and thoroughness of research in some of the special reports named above.

Art-Education applied to Industry. By George Ward Nichols. Pp. 211. With numerous Illustrations. New York: Harper & Brothers. Price, $4.

The title of this work sufficiently indicates its purpose, which is to promote among the people an acquaintance with the principles of art as applied to the products of industry. The author would have these principles taught in all grades of our schools, and offers a scheme of a progressive course of art-instruction which he thinks might easily be adopted by directors of schools in this country. He gives an account of the present state of art-education in sundry European countries, and especially commends the programme of art-education in use in the public schools of Belgium. The work is profusely illustrated.

Linear Perspective. Part I. By F. R. Honey. Pp. 36. With Plates. New Haven: Judd & White. Price, $1.25.

The author of this little treatise, who is instructor in Descriptive Geometry and Perspective in the Sheffield Scientific School, here presents to the student, with all needed clearness, the leading principles of Linear Perspective in the space of a very few pages, and then proceeds to make application of them to perspective drawing. The course of instruction advances by easy steps from the construction of the perspective of a point situated in the horizontal plane to the construction of the perspective of a groined arch and its shadows, and of a spiral stairway.

Annual Record of Science and Industry for 1876. By Spencer F. Baird. Pp. 845. New York: Harper & Brothers. Price, $2.

The "Annual Record," which from the first has been recognized as the very best work of its kind anywhere published, continues to give evidence of the skill and care of its editor. The volume for 1876 contains some notable improvements on all its predecessors. One valuable feature now added is the index of authors and subjects, appended to the "General Summary." Another is the prefixing of the names of Prof. Baird's principal collaborators to the chapters of the "General Summary," written by them. The chapter on "Astronomy" is by Prof. Holden, that on "Meteorology" by

Prof. Abbe, "General Physics" by Prof. Barker, "Chemistry" by the same, "Geology" by Prof. T. Sterry Hunt, and so on, the different departments of "Scientific and Industrial Progress" being attended to by writers of recognized competence. In compiling the second division of the volume, which consists of condensed abstracts of papers on scientific and industrial work, the editor has been assisted by a strong corps of writers, among whom we may name Profs. F. W. Clarke, Cope, F. V. Hayden, Major Powell, and Lieutenant Wheeler.

PUBLICATIONS RECEIVED.

Bible of Humanity. By J. Michelet. New York: Bouton. Pp. 374. Price, $3.

Engineering Construction. By J. E. Shields. New York: Van Nostrand. Pp. 138. Price, $1.50.

Sanitary Condition of Dwelling-Houses. By G. E. Waring, Jr. Van Nostrand. Pp. 145. Price, 50 cents.

Inorganic Chemistry. Vol. II., Metals. By T. E. Thorpe. New York: Putnam's Sons. Pp. 406. Price, $1.50.

Weighing and Measuring. By H. W. Chisholm. New York: Macmillan. Pp. 208. Price, $1.50.

"The Jukes." By R. L. Dugdale. New York: Putnam's Sons. Pp. 121. Price, $1.25.

Daily Bulletin of the Signal Service. With Charts. Washington: Government Printing-Office. Pp. 185.

The Locust Plague in the United States. By C. V. Riley. Chicago: Rand, McNally & Co. Pp. 236. Price, cloth, $1.25; paper, $1.

Physical Geography. By A. Geikie. New York: Macmillan. Pp. 391. Price, $1.75.

General History of Connecticut. By Rev. S. Peters. New York: Appletons. Pp. 285. Price, $1.50.

Report of the Milwaukee School Board. Milwaukee: Keogh print. Pp. 396.

Compendium of Facts and Events. By E. Emery. Peoria, Ill.: *Transcript* print. Pp. 517. Price, $8.

New Constructions in Graphical Statics. By H. T. Eddy. New York: Van Nostrand. Pp. 62. Price, $1.50.

Telegraphic Determination of Longitude. By Lieutenant-Commander F. M. Green, U. S. N. Washington: Government Printing-Office. Pp. 102.

Metallurgical Review. Vol. I., No. 1. Monthly. New York: David Williams. Pp. 100. Price, $5 per year.

Report of the Peabody Museum. Cambridge: Printed by order of the Trustees. Pp. 167.

Brooklyn Monthly. G. F. Beecher, editor. Vol. I., No. 2. Pp. 18. Price, $1 per year.

Relations of Pain to Weather. By Dr. S. W. Mitchell. Philadelphia: Collins print. Pp. 25.

Photograph of the Trotting Horse Occident. By Muybridge. San Francisco.

Fishes of Upper Georgia. By D. S. Jordan. Salem Press print. Pp. 70.

Molecule and Atom. By G. F. Barker. From Proceedings of American Association. Pp. 23.

Heredity. By Dr. E. N. Brush. Buffalo: Hausman & Burow print. Pp. 12.

Personal Appearance. By T. S. Sozinskey, M. D. Philadelphia: Allen, Lane & Scott. Pp. 196. Price, $1.25.

Materialism and Pedagogy. By W. H. Wynn. Gettysburg, Pa.: Wible print. Pp. 22.

Brain of Procamelus Occidentalis. By E. D. Cope. Pp. 4. With Plate.

Green River Shales. By E. D. Cope. Pp. 10.

Rationale of compressing Cotton. By S. H. Gilman. New Orleans: Hyatt print. Pp. 52.

Lectures and Essays. By Dr. V. W. Blanchard. New York: Blanchard Food-Cure Company. Pp. 67. Price, 10 cents.

Hay-Fever. By Dr. E. J. Marsh. Newark, N. J.: Hardham print. Pp. 26.

New Method in Solar Spectrum Analysis. By S. P. Langley. From *American Journal of Science and Art.* Pp. 6.

Anglo-American Primer. By Elieza Bœrdman Burnz. New York: Burnz & Co., Fonetic Publishers. Price, 15 cents.

Annual Meeting of the Free Religious Association (1877). Boston: The Association. Pp. 95. Price, 40 cents.

Venous Circulation. By Dr. W. F. Glenn. Nashville: Marshall & Bruce print. Pp. 4.

Pacific School and Home Journal. Vol. I., No. 6. San Francisco: Lyser & Co. Monthly. Pp. 40. Price, $2 per year.

Darwin on Fertilization of Flowers. By T. Meehan. From *Penn Monthly.* Pp. 10.

The Glacial Period in the Southern Hemisphere. By T. Belt. From London *Quarterly Journal of Science.* Pp. 30.

Serpent and Siva Worship. By Hyde Clarke and C. S. Wake. New York: Bouton. Pp. 48. Price, 50 cents.

The American Bison. By J. A. Allen. Washington: Government Printing-Office. Pp. 144.

A Scientific Course of Study. By C. E. Bessey. Grinnell, Iowa: *Aurora* print. Pp. 11.

Electrical Conduction. By R. C. Kedzie. Pp. 8.

Criminality. By Dr. W. G. Stevenson. From the *Sanitarian.* Pp. 23.

Glacial Ice Deposits. By G. Sutton. From Proceedings of American Association. Pp. 7.

American Homœopathist (monthly). Vol. I., No. 1. Chicago: Chatterton & Co. Pp. 40. Price, $2 per year.

Notes from the Chemical Laboratory of Johns Hopkins University. Pp. 16.

Proceedings of the Davenport Academy of Sciences. Vol. II., Part I. Davenport *Gazette* print. Pp. 148. Price, $3 per volume.

Inscribed Tablets from Davenport, Iowa. Pp. 22. With Plates. From the same.

Heredity, Pauperism, and Crime. By Dr. E. H. Parker, of Poughkeepsie, N. Y. Pp. 12.

School Discipline. By J. Kennedy. Syracuse, N. Y.: Davis, Bardeen & Co. Pp. 23.

Electrometers. By J. T. Bottomley. New York: Macmillan. Pp. 33. Price, 20 cents.

Veratrum Viride. By Dr. J. S. Lynch. Baltimore: Innes & Co. print. Pp. 8.

POPULAR MISCELLANY.

The American Association for the Advancement of Science met at Nashville, Tennessee, on Wednesday, August 29th, Prof. Simon Newcomb presiding. The sessions continued for four days. Prof. O. C. Marsh, of Yale College, was elected President of the

Association for the present year; Prof. R. H. Thurston, of the Stevens Technological Institute, Hoboken, Vice-President of the Physical Section; Prof. Augustus R. Grote, Vice-President of the Section of Natural History; Prof. H. Carrington Bolton, of Columbia College, New York, General Secretary; Prof. Francis E. Nipher, St. Louis University, Secretary of Section A; George Little, Atlanta, Georgia, Secretary of Section B; William S. Vaux, Philadelphia, Treasurer; chairman of Chemical Sub-section, Prof. F. W. Clarke, of the University of Cincinnati. The Association will meet next year in St. Louis, on the third Wednesday of August. The address of Prof. O. C. Marsh, as Vice-President of Section B, at the Nashville meeting, on the "Introduction and Succession of Vertebrate Life in America," was a paper of extraordinary interest, embodying the results of its author's fruitful researches into the paleontology of this continent. Prof. Grote advocated the creation of an International Scientific Service, or organization for the advancement of knowledge. We shall in future numbers of the Monthly publish abstracts of some of the more interesting papers read at this meeting of the Association.

The Cinchona Alkaloids.—Of all the species of cinchona-trees planted in the Nilgiri Hills district of India, the red-bark, or *C. succirubra*, has succeeded best; indeed, none of the other species appear to thrive in the Nilgiri plantations, and they are rapidly giving way before the red-bark cinchona-tree. The bark of the latter contains only a small proportion of the alkaloid quinine as compared with the other three principal alkaloids—cinchonine, cinchonidine, and quinidine—and hence the promise of an abundant supply of the first-named alkaloid from the Indian plantations is not fulfilled. Hence, if the febrifuge properties of the cinchona were confined to the alkaloid quinine, we should have to pronounce these plantations a failure. But it appears to be still an open question whether quinine is entitled to this preëminence. Indeed, there is good reason for believing that the kind of bark which earned for the cinchona-tree its reputation had for its predominant alkaloid cinchonidine. Within a few years, medical commissions have been appointed in Madras and Bombay to determine the respective values of the four alkaloids as febrifuges. The result arrived at by the Madras commission, as stated by Dr. B. H. Paul, in a paper read before the London Society of Arts, was to the effect that, "in recent cases of uncomplicated paroxysmal fever, there did not seem to be any great superiority of one cinchona alkaloid over another." The numerical results on which the commission founded its conclusions were as follows:

		Cured.
Treated by cinchonine	410	400
" " cinchonidine	359	346
" " quinidine	376	365

In subsequent trials these alkaloids were compared with quinine, and the total number of cases treated was 2,472, and of these 2,445 were cured. The ratio of failure per 1,000 cases was as follows:

Quinine	7.092
Quinidine	6.024
Cinchonidine	9.925
Cinchonine	23.255

Which appears to show that the first three are nearly equal in their febrifuge properties.

Treatment of the Opium-Habit.—The English Church Mission supports at Hangchow, China, an "opium-refuge," or hospital for the treatment of smokers of opium. The capacity of this hospital, as we learn from the *Journal of Inebriety*, is for about thirty patients, and there are generally about as many applications for admission as can be granted. Persons wishing to be admitted make their applications on or before the beginning of a month; all the patients for one month being admitted on the same day, and remaining in the hospital for three weeks. In this way, twelve classes of patients are turned out each year, and there is one week in each month for cleansing the hospital. The treatment is directed simply to relieving the *malaise* and depression caused by discontinuance of opium, and the physician in charge states that at the end of three weeks the patients can entirely dispense with the drug without physical inconvenience. One strange fact is developed by this benevolent enterprise. Some of the patients enter the refuge without any desire of giving up opium. They have gone so far that a large quantity is required to satisfy

their craving—larger than they can afford to buy. By submitting to hospital treatment they can get back to a point where a moderate quantity of the drug will produce the desired effect. "They only wish to get up-hill, that they may have the pleasure of sliding down again!" Even in his dissipations the Chinaman shows his characteristic wariness.

Silver-bearing Sandstones.—A correspondent of the *Engineering and Mining Journal* describes the "silver sandstone" formation occurring in the vicinity of Leeds, a village in the southwestern corner of Utah, about 300 miles from Salt Lake City. The formation is a beautifully-stratified red and white sandstone, but greatly broken up and eroded. Where the strata have been undisturbed, they rise to a height of perhaps 1,000 feet above the valley in table-mountains, alternately banded with red and white. The numerous foldings and contortions of the strata are accounted for by the presence of many extinct volcanoes, while the great sandy deserts, covered with sage and cactus, bear abundant evidence of the erosion. On the northern side of what was once a vast basin, lying between several ranges of high mountains of old rock, where the erosion of an anticlinal has left ridges or reefs cropping out at various angles, are the mines. The sandstone consists of red and white deposits, carrying some lime as a cementing material, with occasional layers of clayey or shaly rock, and a considerable amount of carbon scattered throughout. The white sandstone seems so far to have carried the ore, but all the strata carry it in greater or smaller quantity. Careful samplings and analyses show that there is a large amount of ore running from $20 to $50 per ton—in several beds, a foot or more in thickness, averaging from $50 to $200, while others have streaks of various widths, from one to ten inches, yielding ore from $200 to $1,200.

Specimens of so-called "silver-mud" from Oregon have been examined by Mr. Henry G. Hawks, member of the California State Geological Society, who found the substance very rich in silver in the free state, though the microscope failed to give any clew to its origin. It has been suspected that this "silver-mud" is an artificial product, intended to subserve fraudulent designs, but Mr. Hawks could not find any evidence of fraud. If the free silver in the mud were filings, a single glance would suffice to detect the fact. Had the silver been precipitated from solution by copper, it would have been crystallized. An amalgam of silver and mercury would have yielded a sublimate if strongly heated in a glass tube closed at one end. Such amalgam introduced into the wet mud, and the whole heated sufficiently to volatilize the mercury, would have left the substance in a hard-baked state, which could not again have been reduced to the state in which the mud was when it came into the hands of Mr. Hawks. The author finds a close resemblance between this "silver-mud" and the silver-bearing "sandstone," so called, of the preceding paragraph.

Anthropology in Germany.—A writer in *Das Ausland* directs attention to the neglect of anthropological research in the great schools of Germany. The science of anthropology, he remarks, together with all its subordinate branches, such as anatomo-physiological anthropology, ethnology, ethnography, "prehistory," and comparative archæology, were substantially founded by German scholars, as Keller and Virchow, Schaaffhausen and Bär, yet hitherto they have been assigned no official place in higher education. There is not in all Germany a single professorship of anthropology, though that is a subject that interests the entire cultured public. "With us," he writes, "the four antiquated Faculties still profess to represent science in its totality. In France, the case is different. Schaaffhausen, in his account of the Prehistoric Congress of Buda-Pesth, observes that in Paris a professorship of anthropology has been in existence for the last twenty-seven years. Besides, we learn of the recent establishment in Paris of a school of anthropology. This school consists of four sections, of anatomy, biology, ethnology, 'prehistory,' and linguistics, with Broca, Jopenard, Dally, Mortillet, and Hovelacque, for professors. In Germany two scientific men lecture on anthropology, namely, Ecker in Freiburg, and O. Jäger in Stuttgart."

Distribution of the Seventeen-Year Locust.—Mr. L. G. Olmstead, of Fort Edward, sends us an account of a recent interview with Dr. Asa Fitch, the distinguished entomologist of Salem, New York, from which we extract the following particulars concerning the habits and geographical distribution of the seventeen-year locust, which has but lately planted the seeds for the crop of 1894:

"The seventeen-year locust, the *Cicada septemdecim*—thus named by Linnæus, the prince of natural historians—has just made its regular visit to the woods north of Clark's mills, below Fort Miller Bridge, on the Hudson River. Fort Miller Bridge is their extreme northern limit. From time immemorial they have appeared on the same spots. If the woods are cleared up, they resort to the nearest orchards. They are found from this locality south along the Hudson, on through New Jersey, Delaware, Pennsylvania, Maryland, Virginia, the Carolinas, and Georgia. They come out in immense numbers, the woods resounding with the din of their notes.

"There is an annual *Cicada* which appears in dog-days, whose shrill note is quite different from the seventeen-year locust. The notes of this last are not unlike those of the tree-toad, and they were heard at Clark's mills above the noise of the machinery.

"They sing when the sun shines. When growing old their note is much more feeble. The males alone sing; the females are silent, and this has given rise to the distich:

> 'Happy are the *Cicadas'* lives,
> Because they all have voiceless wives.'

"This is their fourth visit that the doctor has observed. He has gathered and confined scores of them, under netting on an apple-bush to keep them from being devoured by birds, which collect to feed on them in immense numbers, as do the swine, and such wild animals as skunks, weasels, etc.

"The locusts puncture the bark of trees and live on the juice. They do not disturb herbaceous plants. They pierce the twigs and deposit two eggs in each puncture, which are probably male and female. The grub hatches and drops to the ground, into which it is said to go to great depths, and is seventeen years in getting its growth. They sometimes come up in the bottom of newly-dug cellars, and where roads are made across districts they have occupied, and they work themselves up through the hardest beaten highway. On coming out of the ground they immediately pair, and the female commences boring the twigs and depositing her eggs, which occupies her about three weeks, when they die and disappear. They never do any appreciable injury to the trees. This seventeen-year locust is not found in any other part of the world.

"They left Fort Miller about the 25th of June, leaving an appointment to hold another great concert on the same ground in 1894. The twigs of witch-hazel, poplar, maple, hickory, oak, etc., are beautifully punctured and as regularly as the stitches on a horse's harness, thus—

Sometimes there will be two rows on the under side of the same twig, thus—

Many twigs of the oak have died from the puncturings.

"There is also a third species of locust in this county, of which only a very few appear. The species of *Cicada* are numerous in warm climates. The doctor has in his collection ninety-two species. He has the three found in this county; others from Pennsylvania, Illinois, Arkansas, Mississippi, Alabama; the Bahama Islands, Jamaica, Venezuela, Brazil, Colombia, Chili; a number from France, Spain, Italy, Egypt, Algiers, Cape of Good Hope, Senegal, Madagascar; the Crimea, Sylhet (a part of British India), Borneo, Java, Ceylon, Assam, Malacca, and New Holland."

Cremation of Dr. Charles F. Winslow.—The following, from a gentleman who took an active part in the cremation of the body of the late Dr. Winslow, at Salt Lake City, on July 31st, contains many interesting details concerning this event not before published:

"Dr. Winslow always had a dread of being buried in the ground; perhaps not a dread, but he had seen many bodies that had suffered the slow decomposition and ravages of the worms, and the thought was disgusting to him. His heart was taken out and embalmed, placed in a jar,

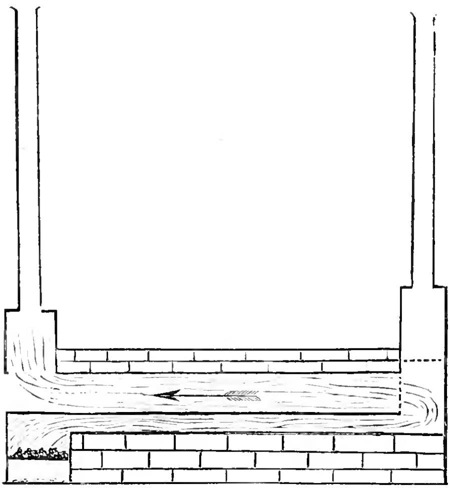
and is to be buried within the grave of his mother. As soon as his executor (and personal friend) reached here, it was decided to proceed with the cremation, but, before it was done, his children at the East intervened, and the operation was delayed. One of his sons came here, and, after reading the will and talking with his (the doctor's) friends, to whom the doctor had so often expressed his views in favor of 'cremation,' decided that it ought to be done, and wrote to the other children for their consent, which they finally granted. In the mean time the body had been embalmed, and kept continually packed in ice.

"Dr. Hamilton, who had charge of the 'cremation,' consulted me as to the means of doing it. They had talked of taking the body to one of the reverberatory furnaces, as they wanted it done quickly—in fact, before his children would know of it. I thought a furnace could be built quickly and cheaply that would answer the purpose, and designed one, as per inclosed rough sketch.

"I will admit that many improvements could have been made on it; but, when you consider that in six hours from the time it was commenced a fire was built in it, I think you will say we did well. Time and expense were the obstacles I had to overcome. The interior of the furnace was six feet by two; the bottom was of boiler-iron, three-eighths of an inch thick; the roof of fire-tiles, two feet long and one foot wide. This enabled us to cover without an arch. The door for the admission of the body was at the south end. You will notice two stacks; the extra one was made so that we could shut off the flames by means of a damper, enabling us to put the body in, and also to view the action without the flame approaching the door. You will see that the flame, when the furnace was at work, passed under the floor the whole length, and then returned over the body and up the stack at the south end of the furnace. In the operation we used the coal from 'Rock Springs,' on the Union Pacific Railroad.

"It was intended to 'cremate' immediately on the completion of the furnace, but Dr. Hamilton had doubts as to the working of the furnace; so he placed in it a quarter of beef, and found it to produce the desired result on this in one hour and five minutes; and, while this was going on, word came to stop it all.

"Finally, all was arranged on the 31st of July; the body, then weighing 126 pounds, was placed on a sheet of iron one-eighth of an inch thick, turned up at the sides and end, and introduced into the furnace, which was at a full-red heat, at 6.20 P. M. The dampers were opened, and the flame allowed to pass directly over the body. For some time quite a '*boiling*' took place, and lasted until most of the moisture had been driven off; in about an hour nearly all the flesh was consumed and the heat was raised. At the end of two and a half hours all action was at an end, but five minutes more was allowed, when the fires were drawn and air admitted to the furnace. In about half an hour the plate was drawn, and the bones gathered up; they were perfectly white and friable, so much so that they could be easily crushed in the hand. After this we rubbed the bones in an iron mortar, and passed them all through a flour-sieve, making in bulk about one quart, and in weight about four pounds. From the time the body was put into the furnace until the ashes were ready for the urn was four hours and forty minutes.



FURNACE IN WHICH THE CREMATION WAS PERFORMED.

"From the construction of the fur-

nace we had perfect control over the heat. I did not wish to have it too hot at the time of placing the body in it for fear of an excessive generation of gases, but I believe we would not have gained anything by having the heat any more intense; from my observation I am convinced that the heat required is not so great as generally supposed: the action of the heat on the lime gives it the appearance of being intensely hot, but at the same time I noticed that the end of the plate where the flame turned was barely altered—just scored a little, as if it had approached nearly to the melting-point.

"The furnace did not cost $100, and I suppose about 1,000 pounds of coal were consumed."

Signs of Advance in Medical Science.—A significant communication has appeared in the English medical journals, namely, a letter to Dr. B. W. Richardson, from George Wyld, M. D., Vice-President of the British Homœopathic Society, in which the latter pleads for a reconciliation between homœopathists and practitioners of the regular school of medicine. Dr. Wyld in effect maintains that the art and science of medicine, as understood by the homœopathists, so called, of England, and by the regular profession, are now the same. Hahnemann, in his famous essay, entitled "The Medicine of Experience," had made no mention of homœopathy, and the doses there recommended were tangible, not infinitesimal. But, as his views were scornfully rejected by the medical profession of the time, Hahnemann, in his turn, became intolerant of the views received by the medical profession, and, "out of spite," as one might say, adopted the doctrine of the efficacy of infinitesimal doses. But everything is now changed, according to Dr. Wyld. "The so-called homœopathists," he writes, "have almost entirely abandoned the use of globules, and have substituted doses in a tangible form. Further, whereas the early homœopathists denounced all auxiliaries in the treatment of disease, it is now the practice to make frequent use of all remedies of a simple kind, such as occasional aperients, anodynes, opiates, anæsthetics, galvanism, hydropathy, Turkish baths, and mineral waters. In short, we define our practice as rational medicine, including the application of the law of contraries, but *plus* the application of the law of similars." Dr. Wyld adds that the sentiments he expresses are held by a large number of homœopathic practitioners. He believes that were physicians of his school to be admitted to the regular medical societies and to the pages of regular medical journals, it would not be long before all sectarianism in medicine would be at an end. He demands the same liberty of opinion in medicine as in religion or politics, and an amalgamation with the regular profession on equal terms. Dr. Richardson asks his brethren to "accept this intended message of peace and good-will in the spirit in which it is written and offered."

Experiments with Viper-Poison.—In the *Zeitschrift für Biologie*, Valentin states the results of his researches on viper-poison. The particular species of vipers employed was the *V. aspera* of Linnæus. Only one viper out of twenty could be made to bite by external irritation. One viper was made insensible under the influence of ether, and Valentin took the opportunity of squeezing out some of the poison on squares of Swedish filtering-paper; he also obtained some of the transparent mucus which had collected on the palate near the apices of the poison-fangs. A fragment of this paper a few millimetres square placed under the skin of the back of a frog generally caused death in from six to twenty hours, the cause of the fatal results, the author thinks, being due to the admixture of some of the yellow, oily secretion of the poison-gland with the saliva. Paper impregnated with the poison retained its activity for six months or more, and enough was obtained from one animal to saturate twenty pieces of filtering-paper presenting twenty to thirty-five square millimetres of surface. It was found that a quantity of the poison not exceeding 0.00037 of a gramme is capable of producing, when inserted beneath the skin of a frog, well-marked and persistent symptoms of poisoning and death in thirteen days; and quantities varying from one-half to one milligramme killed a frog in from eight to twenty hours.

NOTES.

According to an estimate made by the Berlin Statistical Bureau, the total steam motive-power actually in use throughout the world is equal to 13,500,000 horse-power, or to the working force of 25,000,000 horses.

Some grains of wheat left in Polaris Bay (north latitude 81° 38′) by Captain Hall's expedition, in the year 1872, were carried to England by Captain Nares last year. Though they had been exposed for four years to the intense cold of that high latitude, these wheat-grains germinated on being sown in a pot of earth at the Botanic Garden, Kew.

A Papier-maché coating for the bottoms of iron-ships is proposed by Captain F. Warren, who states that weeds and barnacles will not adhere to this material. The special cement by which it is secured may be applied cold, hardens under water, is unaffected by high temperature, and possesses great tenacity. A plate thus protected on one side was immersed for six months, and then the protected side was found clean, while the unprotected metal was covered with rust and shell-fish.

The schooner Florence, *avant-courrier* of Captain Howgate's proposed expedition to the north-polar regions, sailed from New London on the 2d of August, with the design of establishing a colony of explorers on the north shore of Cumberland Island. This island forms the western shore of Davis Strait, and lies between parallels 64 and 68 north latitude and between the meridians 62 and 78 west longitude. The party which goes out in the Florence is supplied with provisions sufficient for one year, or until the arrival of the main expedition under Captain Howgate, which is expected to sail in July of next year. The ship's officers and scientific staff of the Florence are as follows: Master, George E. Tyson, of Polaris fame; first-mate, William Sisson; second, Dennison Burrows; steward, Eleazar Cone; meteorologist, Orray T. Sherman; naturalist, Ludwig Kumlin. Mr. Sherman is a graduate of Yale College. Mr. Kumlin is sent under the auspices of the Smithsonian Institution. The vessel's crew consists of picked seamen.

The first "telephonic line" for practical use has been set up by Mr. C. Williams, of Boston, connecting his place of business in that city with his residence in Somerville, a distance of about three miles. By this line "conversation," Mr. Williams says, "can be carried on nearly as well as if those conversing were in the same room."

The "Transactions" of the American Society of Civil Engineers for June contains an interesting discussion on the subject of the preservation of timber, besides minutes of meetings and several articles of importance mainly to engineers.

A year or two ago, Prof. Bolton, of Columbia College, had some combustible material in his laboratory set fire to by rays of light concentrated by a globular glass jar filled with water. A similar accident lately occurred in Paris, a number of cartridges being ignited by solar rays concentrated by an "eye" in a window-pane. A terrific explosion resulted. "Similar catastrophes," says *Nature*, "are more common than is generally supposed in summer, the windows of railway-carriages igniting sometimes over-dried plants, or even leaves fallen on railway embankments. It is known that fires sometimes occur in Algerian forests through drops of water suspended to the leaves and forming lenses."

The climate of Victoria and other parts of the continent of Australia has been highly commended as of benefit to consumptive patients; but the official statistics appear to prove the contrary. From an "Analysis of the Statistics of Phthisis in Victoria," it appears that the disease is as common and as constant in Melbourne and its suburbs as in England, both among the immigrants and the native-born whites.

In 1843, as we learn from a writer in the *American Naturalist*, a white-maple tree (*Acer dasycarpum*) in the town of Stockbridge, Massachusetts, measured twelve feet in circumference at three feet above the ground. In October, 1876, the tree was, at the same height from the ground, fifteen feet nine inches in circumference. Thus the average annual increase of circumference was about 1.36 inch.

The London Geographical Society has declined to coöperate with the International Association for the Exploration of Africa founded by the King of the Belgians, and favors independent work by the English. To promote the accomplishment of this work a fund is to be raised, and the Geographical Society has already made a special donation of £500. It is estimated that a well-equipped exploring expedition will cost £1 10*s.* for every geographical mile of country traveled in Africa.

The native trees, bushes, and shrubs, of Southern France that are most sensitive to cold during extreme winters are by Martins held to be *survivors* of the flora which covered the same area during the Middle Tertiary; they are exotic as to *time*, as other plants are exotic as to *space*.

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